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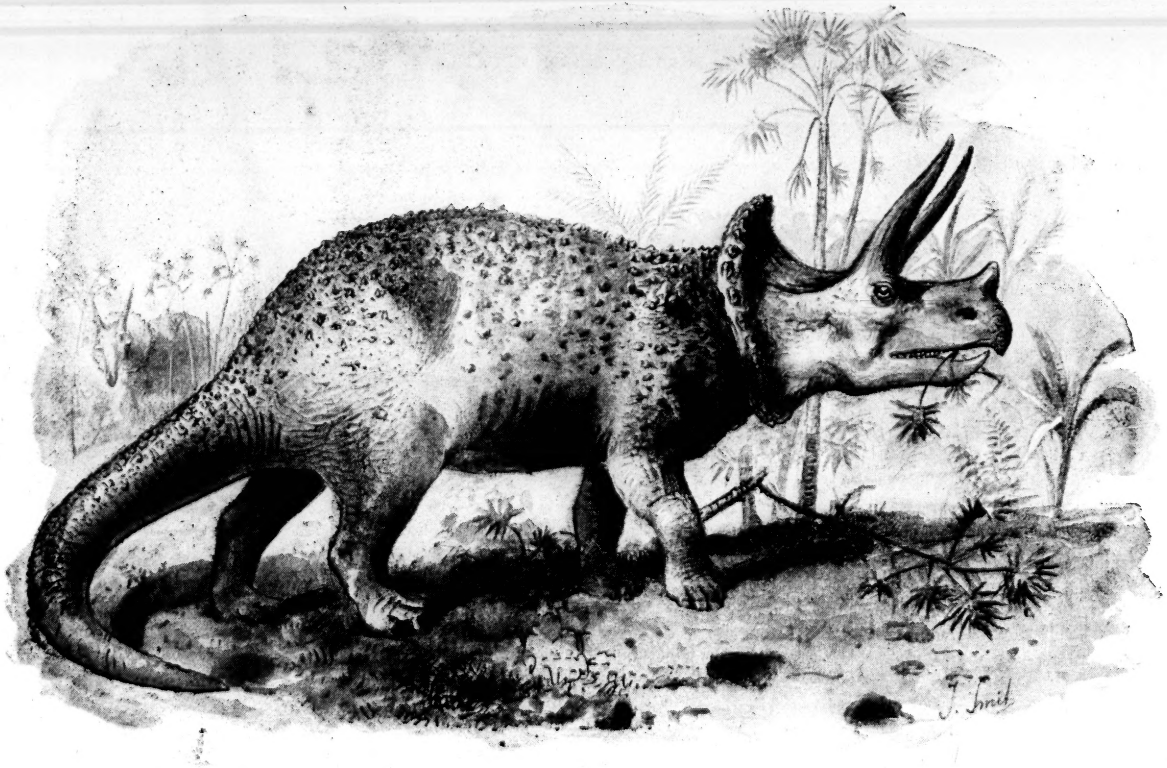
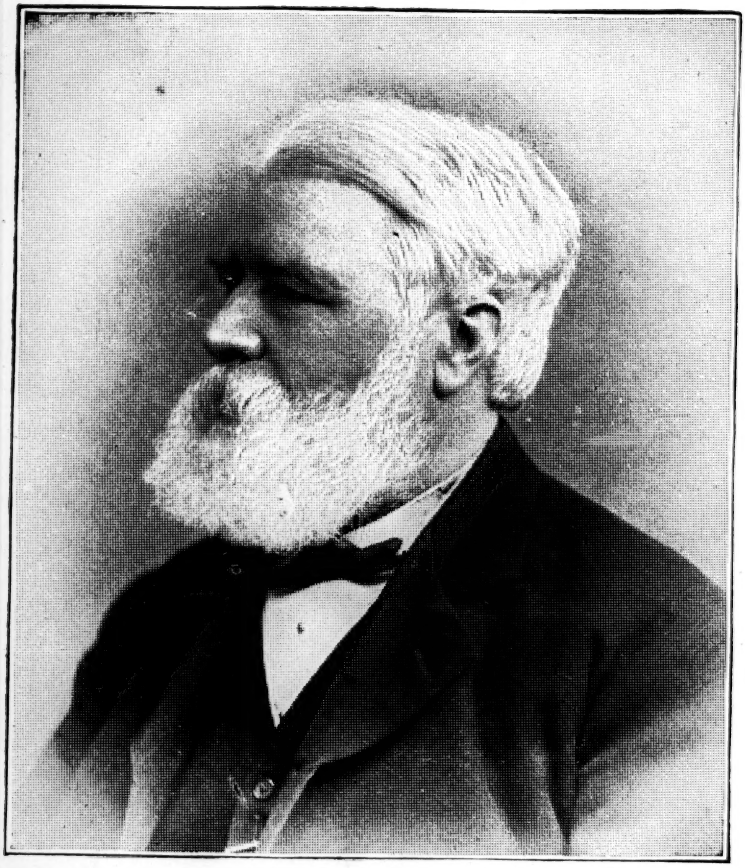


A GIGANTIC HORNED DINOSAUR TRICERATOPS PRORSUS. (MARSH.)

From "EXTINCT MONSTERS." CHAPMAN & HALL LD. 1892.)



GEOLOGICAL MAGAZINE, DECADE III. VOL. X. NO. I. JANUARY, 1893.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. I.—JANUARY, 1893.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists. No. 7.

Professor Thomas Rupert Jones, F.R.S., F.G.S., etc.

(With a Portrait.)

THE commencement of the thirtieth year of the publication of the Geological Magazine appears to be an appropriate occasion to offer a short account of the life and work of one who for the first twelvemonths Edited, with Henry Woodward, this Journal, and has, ever since, been one of its most regular contributors.

Thomas Rupert Jones was born October 1st, 1819, at Wood Street, Cheapside, and is the son of John Jones, Silk Merchant and Silk Throwster, of London and Taunton, a descendant of the old Powys family of North Wales, and Rhoda Jones (*née* Burberry) of Coventry. He was educated at Foster's, at Taunton, and the Rev. John Allen's, at Ilminster. It was during his schooldays at Mr. Allen's that Rupert Jones was first attracted to a love for geology, by observing the Ammonites scattered plentifully about in the quarries of the Upper Lias at Ilminster. Curiously enough the late Mr. Charles Moore was also led to become an enthusiastic student of geology by seeing the same quarries and their fossils, as a schoolboy, about the same time. Later on, when apprenticed to Mr. Hugh Norris, Surgeon, at Taunton, Somerset, in 1835, he observed that the walls were built of Lias stone, and contained fossils. Here he read with interest "Parkinson's Organic Remains of a Former World," which appears to have exercised a powerful influence over his youthful mind. After the death of Mr. Norris he finished his apprenticeship with Dr. Joseph Bunny, of Newbury, Berks, in 1842.

After some years of medical and scientific education he was, in 1850, appointed Assistant-Secretary to the Geological Society of London; Lecturer on Geology at the Royal Military College, Sandhurst in 1858, was made Professor in 1862, and subsequently also appointed to the Staff College.

He was author of a "Monograph of the Cretaceous Entomostraca," in 1849; and of "The Tertiary Entomostraca of England," in 1856; and a Monograph of the Fossil *Estheriæ*," 1862; he wrote the article "*Tunicata*," in Todd's "Cyclopædia of Anatomy," 1850; and articles in Cassell's "Natural History," "Science for All," and the "Encyclopædic Dictionary." Prof. T. R. Jones is also author of numerous articles and memoirs on Geology, Palæontology, and Prehistoric Man, and especially on recent and fossil Entomostraca and Fora-

minifera, in the Quarterly Journal of the Geological Society, the Natural History Review, the Annals and Magazine of Natural History, the Geologist, the GEOLOGICAL MAGAZINE, the Proceedings of the Geologists' Association, and other periodicals.

He is joint author of the "Monograph of the Arctic and North-Atlantic Foraminifera," 1865; the "Foraminifera of the Abrohlos Bank," 1888; the "Foraminifera of the Crag," 1866; the "Nomenclature of the Foraminifera," in 15 Parts, 1859–72; of the "Micrographic Dictionary," 1874 and 1882; of a "Monograph of the Carboniferous *Cypridinadæ*," 1874 and 1884; of the "Palæozoic Phyllopoda," 1888–92; "Geology," Part I. Heads of Lectures, etc., 1870; and of numerous papers on Carboniferous and other Entomostraca. Professor Jones was the editor of the "Arctic Manual," issued by the Admiralty in 1875; and the editor and joint author of the "Reliquiæ Aquitanicæ," in 17 parts, 4to., 1865–75, pp. 530, with 90 plates; and of the second edition of "Dixon's Geology of Sussex," 1878.

He was formerly Examiner to the London University, the Victoria (Manchester) University, and the New Zealand University; and is now Examiner to the College of Preceptors; Assistant-Examiner to the Civil Service Commission, and to the Department of Science and Art. He was elected a Fellow of the Royal Society in 1872, and of the Geological Society of London in 1852, and is an Honorary Member of numerous scientific societies, both British and Foreign.

In presenting the Lyell Medal of the Geological Society to Prof. Rupert Jones, February 21, 1890, the President, Dr. W. T. Blanford, said: "There is unusual pleasure in presenting one of the chief awards in the gift of the Council to a geologist who has been so long and so honourably associated with the Geological Society as yourself, and the appropriateness of the award is not decreased by the circumstance that your official connection with the Society commenced when the great geologist, who founded this medal, was President. Since that time, now forty years ago, you have written much on various fossil organisms, but especially on the Entomostraca and Foraminifera, and in many cases, and especially amongst the Bivalved Crustaceans of the older rocks, it is largely to your researches that we are indebted for our present knowledge of these forms. You have also devoted much time and attention to the Geology of South Africa, and to bringing together the scattered information that we possess concerning the geology of that interesting region. I think that the Council have carried out the intentions of Sir Charles Lyell, and that they are justified in believing that, in his words, 'the Medallist has deserved well of the science.'"

Professor Rupert Jones was elected President of the Geologists' Association, filling that office from 7 February, 1879, to 4 February, 1881. He was a Vice-President of Section C (Geology) at the Meeting of the British Association at Montreal, August, 1884, the only occasion on which the Association visited one of our Colonies; he acted also at subsequent annual gatherings, and was President of the Geological Section at Cardiff in August, 1891. The list of his

separate published papers exceeds one hundred, and he is joint author of nearly half as many more with Dr. Harvey B. Holl, F.G.S., Professor W. K. Parker, F.R.S., Dr. H. B. Brady, F.R.S., Mr. J. W. Kirkby, Dr. H. Woodward, F.R.S., Mr. Chas. Davies Sherborn, F.G.S., Dr. G. J. Hinde, V.P.G.S., and others.

From 1850 to 1865, Prof. Rupert Jones Edited the Quarterly Journal of the Geological Society, and, at the request of the Council, he undertook the editing of the latter half of vol. xlvi. (1890), left unfinished by the lamented death of Mr. W. S. Dallas.

Whether as Lecturer, Professor, Author, or Reviewer, Prof. T. Rupert Jones has always aimed at the advancement of geological science, and although never enjoying a liberal emolument for his professional services, he has never lost his enthusiasm, but laboured on for more than forty years, and is still full of energy and love for that science to which he has devoted his whole life. He has the satisfaction to know that although the pursuit of science is not so remunerative as other professions to which he might have turned his talents, he has nevertheless earned the warm esteem and regard of a very wide circle of friends and fellow-workers who admire his personal character and respect his worth.

II.—Some Examples of Folds and Faults in the Devonian Rocks at and near Ilfracombe, North Devon.

By Henry Hicks, M.D., F.R.S., Sec.G.S.

Introduction.

In a paper read by me before the Geological Society of London on November 26th, 1890,[1] I mentioned that I had obtained evidence during a recent visit to North Devon which had led me to believe that far too little importance had hitherto been assigned to the results of movements in the earth's crust as affecting the succession of the rocks in that area. I mentioned also that the supposed continuous upward succession from the rocks on the shore of the Bristol Channel to those in the neighbourhood of Barnstaple, including, according to some authors, no less than ten distinct groups, was an erroneous interpretation; for the beds are greatly plicated and faulted and several times repeated. Therefore instead of being one continuous series with a regular dip to the south, the beds are much folded in several broken troughs. In this paper I purpose giving some examples of the folds and faults near Ilfracombe which will enable those who visit that neighbourhood to verify the statements which I have made in regard to some of the rocks in that area.[2]

It will be seen that the beds have been constantly inverted and the folds broken, so that older beds have been made to appear to overlie conformably newer beds. The movements have taken place

[1] See Abstract in Proceedings Geol. Soc. No. 562, and Geol. Mag. Dec. 1890.

[2] The Morte Slates, which have always been classed as newer than the Ilfracombe beds, I stated in the same paper to be the oldest rocks in the area, and they are now proved by their contained fossils to be of Silurian age.

mainly in one direction, and the rocks near the fault-planes have been much sheared.

Combe Martin Bay.

In the beds along the East shore of Combe Martin Bay from Hangman Point to Combe Martin, there are many instructive examples of folds and faults. From Hangman Point to Wild Pear Beach there is a succession of thick beds of grits and flaggy sandstones which, at and near the point, dip generally to the south at an angle of about 35°. Nearer Wild Pear Beach they become bent into sharp folds, and at the north-east corner they are cut across by a fault as shown in Fig. 1. The beds north of the fault are mainly red,

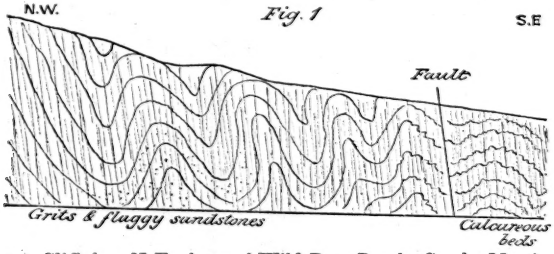


Fig. 1.—Cliff-face N.E. shore of Wild Pear Beach, Combe Martin Bay.

purple, and grey grits and sandstones with some intercalated flaggy beds, but immediately south of the fault flaggy and slaty calcareous beds are met with, here much crushed. In the point which separates Wild Pear Beach from Sandy Bay the flaggy sandstones which, in natural order, overlie the Hangman grits, and which separate the latter from the calcareous beds, reappear bent into acute folds which reach to the top of the cliff, as seen in Fig. 2. Between here and

Fig. 2.—Cliff-face N.E. shore of Sandy Bay, Combe Martin.

Combe Martin the beds are greatly folded and frequently broken, but the succession is easily traceable.

The succession, as seen in the cliffs between Hangman Point and Combe Martin Harbour, indicates such an order of deposition as would accompany a gradual depression with a shore-line not far north of the Hangman Point. The lowest or massive grit and sandstone beds are clearly followed in true succession by the finer flaggy beds, and the latter by slaty and calcareous beds. Certain fossil zones which can be traced often offer evidence to prove that the beds are inverted when the folds are too much broken to be easily followed. Near the crest of the hill north of Combe Martin Church, red and purple grits belonging to the lower or Hangman

beds are again to be seen under the flaggy beds, hence it is clear that another important fault separates these beds from those exposed in the low ground on the north side, viz., the West Challacombe calcareous beds. The succession as traceable in a section in a line south from Combe Martin shows that the flaggy and slaty beds which underlie the calcareous beds rise up higher and higher in the hills until they at last abut against highly cleaved slates of the Morte series type, thereby forming a main trough but containing several subsidiary folds with the calcareous beds occupying the highest stratigraphical position.

In following the coast-line from Combe Martin towards Watermouth, numerous folds in the flaggy and in the calcareous beds are recognizable, and the somewhat complex fold (Fig. 3) is seen in a

Fig 3.

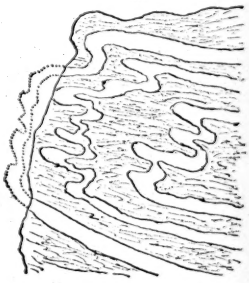


Fig. 3.—Folds in limestone Quarry, road-side, about a mile W. of Combe Martin.

limestone quarry on the roadside, about a mile west of Combe Martin. It will be noticed that the larger folds of the limestone bands, in themselves fairly acute, have developed, during the pressure, numerous minor folds, and that these have, in places, yielded so far to the pressure that the limbs of the folds have been almost brought together. The movements which have taken place have also nearly obliterated all traces of stratification in the associated argillaceous beds by inducing in them a highly cleaved state. Had this fold been subjected to still greater pressure, it would have assumed the condition frequently witnessed in some of the cliff sections, where, owing to the wearing away of the arch of the fold, band after band seem to lie in true succession, whilst in reality they are but the same band several times repeated in an inverted state.

At the Watermouth Caves, and on the shores of Watermouth Bay, several folds occur in the sandstone and flaggy beds. In the one at the Caves the arch has been broken in a line parallel with the strike, and this produced the line of weakness which subsequently caused the indentation or small harbour which occurs here. Fractures here are most frequent across the middle limb which joins the arch with the trough fold, but this is a good example of the effect of denuding forces acting on a broken arch of rather rough sediments affected by strong cleavage.

Hele Bay and Hillsborough.

The beds on the east side of Hele Bay from Rillage Point to Hele Village are, as a rule, intensely folded. The limestone bands are repeated over and over again, and the underlying slates and flaggy sandstone beds are also traceable in broken folds below them. There are also numerous thrust faults which aid in producing the frequent repetitions of the beds. A superficial appearance, owing to the strong cleavage planes, leads one at first to suppose that there is a fairly well-marked succession with a general dip to the south, but a closer examination shows how entirely deceptive this is. The more one examines the beds on this coast, the more one is constantly reminded of the intensely complex arrangements which have been produced by earth-movements. The results in inducing cleavage and foldings on a small scale, in some of the sediments in this area, have been already referred to by Dr. Sorby, F.R.S.,[1] and by Mr. J. E. Marr, F.R.S.,[2] but I was entirely unprepared to find here evidences of such remarkably deceptive appearances in regard to the general succession which gradually made themselves apparent during my researches.

On the west side of Hele Bay the beds are bodily thrown forward by a fault which crosses the beds more or less in the line of the Valley. The section on this side passing through Hillsborough is most instructive as illustrating mountain-making by a series of parallel folds aided by thrust faults, especially as the beds can be examined in cliff sections in Hele Bay on the one side, and also in the precipitous cliffs and coves on the Ilfracombe side. Extending across the hill from the point between Rapparee Cove and Larkstone Beach are fairly gentle folds of sandstone beds, but between here and Beacon Point the folds become steeper and steeper, and at last are so much crushed and broken that the limestone bands in the higher beds near the Point are so cleaved as to look, at a little distance, like slates.

If the section is carried in a line south from Hillsborough it will be found that similar beds to those which form that hill are repeated in wider folds here and there broken across, but which on the whole form themselves into a fairly wide trough in which the sandstone beds mark the boundary on the south at a fault which separates the Ilfracombe beds from the Morte series.

Ilfracombe.

Lantern Hill and Capstone Hill, Figs. 4, 5, and 6, offer illustrations of fairly gentle folds broken on the north or seaward side; the result being a precipitous face on the over fold or broken side and an easy slope on the side of the arch limb. These show the conditions to be witnessed in the majority of the Torrs which are so plentiful in the neighbourhood, especially those formed of the

[1] Q.J.G.S. vol. xxxv. pt. 2, p. 89.
[2] Geol. Mag. 1888, Decade III. Vol. V. p. 218.

massive sandstone beds, which of necessity are of a somewhat unyielding character. These folds also are frequently fractured in lines radiating outwards more or less from the core of the fold, which are quite independent of the cleavage planes. The lateral pressure which has been sufficient to produce these effects on the harder and unyielding

Fig. 4.

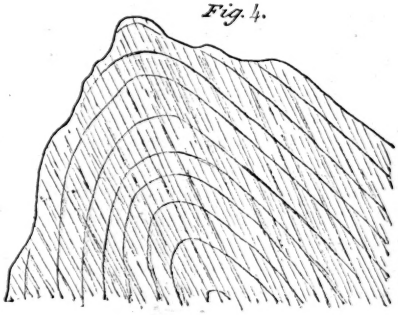


FIG. 4.—Fold in flaggy beds on the shore between Capstone Hill and Lantern Hill, Ilfracombe.

Fig. 5.

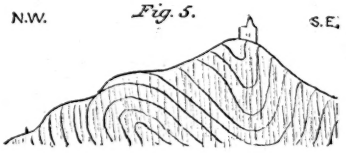


FIG. 5.—Section through Lantern Hill, Ilfracombe.

Fig. 6.

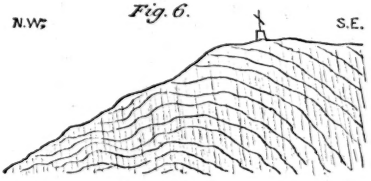


FIG. 6.—Section S.W. face of Capstone Point.

beds, has, as has already been stated in the case of the beds at Hele Bay, affected the softer and more yielding calcareous beds in a far more marked manner. There are many excellent examples of folds in the harder beds on the shore at Ilfracombe which may be easily examined, and which

Fig. 7.

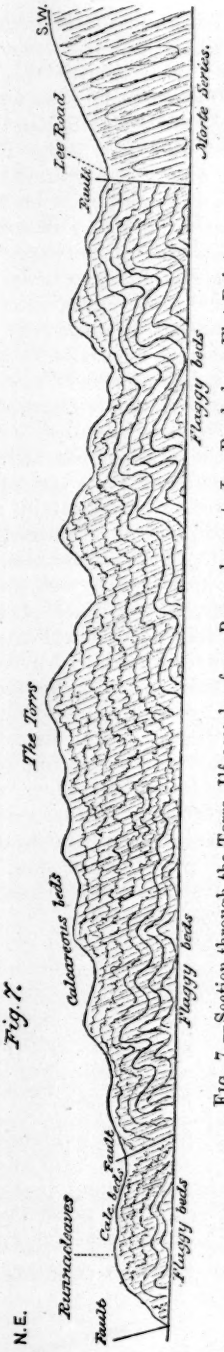


FIG. 7.—Section through the Torrs, Ilfracombe, from Runnacleaves to Lee Road above Flat Point.

exhibit in a marked manner the influence of intense pressure on sandstone and argillaceous material. There are those already referred to on each side of the Rapparee Cove, in the Lantern Hill and in the Capstone Hill, as well as the fold (Fig. 4) between the Capstone and Lantern Hills, and another interesting example on the shore under the Ilfracombe Hotel, all of which can be reached with ease. The glossy appearance of these rocks readily strikes the eye, and on examination it will be found to be due to the combined effects of shearing and of subsequent infiltrations along the crush lines. At Wildersmouth between the Capstone Hill and the Ilfracombe Hotel a fault crosses the beds, which, although not of much importance in regard to the question of succession, is yet interesting as showing the influences produced by cross faults on the physical features of a district, for most of the harbours and valleys in this area have had their direction determined by these faults as being the lines which offered the least resistance to denuding agencies.

Fig. 7 is intended to illustrate the general succession as traceable in the cliffs under the Torrs from near the Ilfracombe Hotel to the ridge beyond the last of the Torrs. At the north end of the section there is the sharp fold in the sandstone beds broken on the north side and much seamed with quartz veins in the line of the thrust fault. This is best seen, as already stated, under the Hotel grounds, but it is equally well shown at the Point outside the ladies' bathing place, where inverted and jagged-looking beds on the north side of the fold form a well-marked ridge. The beds at this horizon are freely covered with worm-tracks, and these offer an easy means of finding out whether the beds are inverted or not when the arch has disappeared. Overlying these beds at the bathing-place are the grit, argillaceous and calcareous bands which were described by Dr. Sorby as illustrating the development of slaty cleavage, and more recently by Mr. Marr,[1] to show some effects of pressure on sedimentary rocks. These beds being composed of softer and more yielding materials than the underlying beds, have given way much more readily to the pressure, and the result has been to induce a strong cleavage in the argillaceous beds which has, as seen in Fig. 8, nearly

Fig. 8.

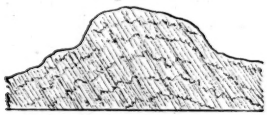


Fig. 8.—Cleavage nearly obliterating bedding in slaty beds, quarry, Torr's Park Road.

obliterated all evidence of stratification, and which has broken the limestone and also some quartz bands into lenticular fragments having their long axes parallel with the cleavage planes.

Beyond this point the calcareous beds rise higher and higher in the cliff, and at last form the central group of Torrs. The Torrs

[1] Geol. Mag. 1888, Decade III. Vol. V. p. 218.

further south are, in the main, composed of sandstones and flaggy beds, but with some of the slaty and calcareous beds also folded in. The sandstone beds may be easily examined on the Lee (Cliff) Road at the junction of the Upper Torr's Walk with the Lee Road, and also on the coast below the last two Torrs. In the cliff, north of Flat Point, the beds are much crushed, and show clearly that there is an important fault separating the beds which compose the Torrs from the highly cleaved slates of the Morte series, which form the high ridge on the south side which intervenes between here and Lee.

It will be seen that the interpretation here given of the succession along the Torrs, and elsewhere in the Ilfracombe district, differs in a very marked manner from that generally adopted. Instead of interpreting the Torrs as formed of outcrops in a succession of hard and soft beds having a regular dip to the south, they are here shown to be due to foldings and fractures of the strata, the wider Torrs with even slopes on the south side being formed mainly of hard and unyielding beds, and the smaller and less regular ones of softer argillaceous and calcareous rocks. The realization of these facts will necessitate, in future, a great reduction in the thickness hitherto given to the Ilfracombe series, and the re-arrangement of the fossil zones. These points will be dealt with further in a forthcoming paper, which will include also the description of the Morte series and its fauna. The Morte slates have been described as entirely barren of organic remains. My researches have now proved that they are everywhere fossiliferous, and that they contain a fairly rich fauna.

III.—Eskdale Drift and its Bearing on Glacial Geology.

By T. Mellard Reade, C.E., F.G.S., etc.

Part I.

THE extraordinary abundance and almost universal distribution of fragments of Eskdale granite through the Drift of the North-West of England and part of North Wales is an impressive fact to the student of Glacial Geology. Mackintosh was the first to systematically trace this rock through the Drift and to note its origin. Since the time of this single-minded and patient investigator many other geologists have gone over the same ground and extended his observations, and all must bear witness to the accuracy of his facts.

In this paper I propose to speak only of the facts of Glacial Geology which I have personally observed, so that absence of reference to the work of others must not be construed into insensibility to their merits. Indeed, were I only to name all the meritorious workers even in this area of Great Britain the space at my disposal would prove all too short.

Distribution of the Eskdale Granite.

In almost every section of Drift from St. Bees, in Cumberland, to the south of Shropshire, and from Macclesfield across to Wales, and

thence along the coast as far as Nevin, in Carnarvonshire, a more or less careful search will yield to the experienced observer some fragments of this rock either as minute pebbles or good sized boulders. It is usually readily distinguished from the Scotch granites by the characteristic prevalence of a light pink felspar and often by a much coarser grain. There is, however, a second variety of granite having its birth in Eskdale which is of a blue-grey colour but still recognizably different to the grey granites of Dalbeattie and Cairnsmore of Fleet.

Pebbles and boulders of Eskdale granite, usually considerably water worn, and bearing none of the characteristic marks of glaciation, are found in the Drift at all levels from 1400 feet above O. D. at Moel Tryfaen to below the sea level in estuaries where engineering works have made us acquainted with the subaqueous glacial drift. Therefore it is remarkable not only for its horizontal, but also for vertical range.

The Parent Rock.

The area and distribution of the Parent rock is shown upon Sheets 98 N.W. and 99 N.E. of the Geological Survey, and are given in outline on Fig. 1, p. 17. It commences at Muncaster Castle in Eskdale, and e xtends up the vale as far as Eskdale Fell. Miterdale, parallel to and to the North of Eskdale, is also excavated in this granite, and it extends over to the foot of Wast Water.

Roughly it may be considered a tract 8 miles long in a south-westerly direction by an average width of 4 miles, and an area of about 32 miles. Its highest part is just south of Wast Water, about 1400 feet above O. D., and it is found at nearly sea-level in the lower parts of Eskdale and Miterdale. In all this area there is only one Granite quarry, and, curiously enough, it is in the bluish-grey variety, which, though an excellent granite, is not at all the distinguishing rock of the Vale. It is at Broad Oak, Waberthwaite, and is worked for monuments, kerbs, setts, etc.

Glacial Drift of Eskdale.

Basal Granitic Drift.—The basal drift lying upon the Granite in Eskdale is composed of angular and subangular fragments and blocks of granite mixed with a smaller number of boulders from the Volcanic series through which the granite was extruded and which surrounds it on all except the seaward side. An angular unstratified granitic sand fills up the interspaces between the stones, the whole having a decidedly reddish hue. I have searched for marks of glaciation on the granite blocks and fragments but very rarely found any. In those few cases where glacial markings were perceptible they took the form of rubbed slightly channelled surfaces without striæ. On the fine-grained volcanics which, as a rule, are more worn and rounded than the granite, fine striations were often seen, but not so often as in the Low-level Marine Drift of the Lancashire plains. Up Eskdale and Miterdale as the Volcanic series are approached boulders of these rocks begin to preponderate.

High-Level Glacial Gravels.

At a level of about 1600 feet above O. D. on the edge of the Screes overlooking Wast Water (see Fig. 1, p. 17) is a deposit of sub-angular gravel so far as I could make out entirely composed of the rocks of the volcanic series. It is about 8 feet thick where I first saw it, and can be traced along the summit of the Screes up to nearly 2000 feet above O. D. Unlike the Drift of the valleys already described, these gravels show marks of glaciation in the shape of flattened surfaces, striæ, and scorings, at all angles.

I brought quite a number of specimens away with me. Many of them have been very much weathered, as might be expected from their exposed situation, but still, even where the stone is much eaten into by surface decomposition, the characteristic glacial shape is often preserved. These gravels show on the north-west edge of the Screes, evidently through the falling of the cliff-rock on which they repose, exposing from time to time fresh surfaces. The rain washing away the smaller material in which they are imbedded, leaves the upper surface of gravel clean and conspicuous. The largest striated stone I observed was 7 inches across, and flat on opposed sides. There is no doubt that the flat surfaces are largely due to jointing, and it is on these plane surfaces that the stones have been pushed along, polished and striated. The smallest gravel is often striated all over, and it is quite evident that the original shape of the stone influences considerably its mode of glaciation.

At Miterdale Head there is a ravine or wash-out in the Drift with which this part of the mountain is deeply covered. Its level, where I examined it, is from 1400 to 1500 feet above O. D. The Drift is here of a very similar character to that on the summit of the Screes, but hardly so much glaciated. On digging into the deposit, a little below the surface-wash, it appeared to be a grey Till.

I think that the Drift on the Screes is probably similar in nature. I took samples of the loamy matter in the Screes Drift, as also in that at the head of Miterdale. A mechanical analysis by means of sieves yielded the following results.

TILL FROM THE SCREES, WAST WATER, 1600 FEET ABOVE O. D.

Weight before washing 6 ounces.

Percentages.		Ounces.
·465	caught in $\frac{1}{20}$ inch mesh	2·792
·069	caught in $\frac{1}{40}$,,	0·416
·100	caught in $\frac{1}{100}$,,	0·604
·208	passed $\frac{1}{100}$,, (fine sand)	1·250
·158	(clay)	0·938
1·000		6·000

TILL FROM RAVINE NEAR MITERDALE HEAD, 1485 FEET ABOVE O. D.

Weight before washing 6 ounces.

Percentages.		Ounces.
·562	caught in $\frac{1}{20}$ inch mesh	3·375
·055	caught in $\frac{1}{40}$,,	0·333
·111	caught in $\frac{1}{100}$,,	0·666
·173	passed $\frac{1}{100}$,, (fine sand)	1·042
·099	(clay)	0·584
1·000		6·000

The material is all more or less angular, and is mainly, even to the smallest grains, from the volcanic series. There are some quartz grains, but none that I could see were rounded or polished.

Marine Boulder and other Drift.

This Drift may be observed in many gravel pits in Eskdale and Miterdale and between Eskdale Green and Santon Bridge. A specially good example of it may be seen in a large gravel pit between Ravenglass and Muncaster Bridge about 270 feet above O. D. (No. 1 on Map, Fig. 1, p. 17).

This Drift is composed to the largest extent of angular, subangular, and very rounded boulders of Eskdale granite. I noticed one very large boulder of grey granite. There were a good many very rounded pebbles of St. Bees sandstone, and I noticed one flat angular piece measuring eight inches across. Two small flints were found here also. Glaciated volcanic boulders and pebbles are next in frequency to the granite. A microscopical examination of the sand which accompanies this Drift shows that it is partly composed of rounded and worn grains of quartz mixed with a larger proportion of angular and subangular grains and broken crystals of quartz evidently derived from the disintegration of the granite. It is on the whole a decidedly large grained sand.

A smaller gravel pit at How Bank between Muncaster Bridge and Eskdale Green, on the left bank of the Esk (No. 2), shows a section of similar gravels and boulders in this case current-bedded. At Harrison's Farm (No. 3) in Miterdale, at about 250 feet above O. D., there are laminated sands horizontally bedded, overlaid with current-bedded gravels of the same series disclosed in a sand and gravel pit.

Between Eskdale Green and Santon Bridge several pits in this series can be seen, noticeably one at 335 feet above O. D. (No. 4), in which is a bed of fine laminated gravel, intercalated in a turbulently bedded stony Drift. The stones are mostly granite, well rounded and showing a brilliant colouring. There are volcanics intermixed, one of which was striated.

On the right hand side of the road in descending towards Santon Bridge an interesting section occurs in a considerable gravel pit having a level of about 320 feet above O. D. (No. 5). The base is composed of a hard reddish buff Till, upon which is sand and fine gravel current-bedded and irregular. Above this is a coarser gravel and there are a good many large blocks mostly Volcanics; one I measured being 5 feet × 4 feet × 4 feet and well striated. Some are of ash and very irregular in shape. Towards the top a few small pieces of St. Bees sandstone occurred, together with another sandstone I took to be Carboniferous. Granites similar to Eskdale are mixed up with the boulders, and are mostly rounded.

There is a considerable development of the Drift on the Wasdale side of the divide.

Drift of the Plain from Santon Bridge to Calder Bridge.

From Santon Bridge to Calder Bridge the country is covered with Drift Sand and gravel, which extends westwards to the coast and

is connected with the Drift of St. Bees. Sections of this sand can be seen on the Rivers Irt and Calder which have deeply excavated into it. It mostly lies upon the Permian Sandstone but overlaps the Volcanics inland near Gosforth where good sections may be observed on the River Bleng. It is undoubtedly marine. The base on which this drift rests may be seen in a quarry of Permian Sandstone above the Bridge over the Bleng at Sourmire (No. 6) about 400 feet above O. D. It consists of hard foliated red sand containing a little clay with angular and subangular pieces of the red sandstone embedded in it, together with pebbles of the Volcanic series.

On the left bank of the Bleng nearly opposite the quarry just described, there is a good section of drift about 25 feet high (No. 7). Here, curiously enough, it is a buff clayey hard till, full of Volcanics, but Sandstones seem to be absent. It lies on the Volcanic series of rocks and there is a large bank of it here. Between Hall Boltom and the bridge carrying the Gosforth road over the Bleng, is a deposit of sand like that on the Irt.

Calder Abbey stands upon a terrace cut out of the Drift which, though looking so recent, is evidently a very old feature estimated by years. It cannot have changed appreciably since the building of the Abbey in 1180, the escarpment bounding the platform on which it stands being quite sharp and unmodified.

Beyond Calder Bridge in the direction of Whitehaven the old river scarp comes up to the road (No. 8). This bank is made up of loamy red sand full of large boulders and pebbles of St. Bees Sandstone exceedingly well rounded, together with rounded Volcanic pebbles. Some of these Sandstone-boulders are a little indented and scratched. I observed here a good sized boulder of Buttermere Granophyre. This Drift is all marine.

Coast Sections.

From Braystones to St. Bees are very good sections of this sand and gravel Drift which I have described in part in my paper "On the Drift Beds of the North West of England and North Wales."[1] South of Nethertown Station there is a good section of sands and gravels. At the south end of the section are blocks of St. Bees sandstone up to five feet across, embedded in the Drift. Near here my son Aleyn found an indented boulder of fine soft Yellow sandstone, probably Carboniferous, also partly covered over with a deposit of carbonate of lime cementing the gravel thereto. Coal flakes in laminæ occur in the sands, and also shell gravels. The sand grains are large and well rounded. At the north end is the Faulted Drift described in the GEOLOGICAL MAGAZINE for November, p. 490.

Among the Drift stones are a good many rounded pebbles and some boulders of Eskdale granite, and these are found all along as far as St. Bees. The sections of Drift at St. Bees before referred to as described by me in 1883 (but seen in 1872) are not now so clear, being covered by a good deal of talus-wash, but sufficient is seen to show that the beds now exposed differ considerably from

[1] Q.J.G.J. vol. xxxix. (1883), pp. 108–111.

those observed in 1872, though the principal characteristics remain the same.

Marine Drift in the Valley Bottoms.

In the flat bottom land between and connecting the valleys of Miterdale and Eskdale, between Irton Road and Eskdale Green stations on the narrow gauge railway, is a deposit of sand, gravel, and boulders (No. 9).

The boulders and gravel lie upon fine laminated sand, and are of well rounded Eskdale granite, both pink and grey, together with a good many Volcanics. Intermixed with them was a large percentage of extremely well rounded pebbles of St. Bees sandstone up to four inches diameter. The level is about 145 feet above O. D., and they must have travelled up either Miterdale or Eskdale, probably Eskdale. As this drift lies on the granite and the Permian sandstone is at the nearest point in Miterdale between two and three miles to the westwards, and in Eskdale four miles, it must have travelled at least the minimum distance stated up one of the valleys, but probably much more.

At the private bridge over the Esk, near Muncaster Head (No 10), there is a section of this sand-drift, here all sand, full of extremely rounded and very small pebbles of St. Bees sandstone. The sand possesses all the characteristics of Marine sand, consisting principally of very rounded quartz grains, intermixed with angular unworn grains, evidently the débris of the granite. I believe that the worn grains are also of the same derivation, as they are much larger than those of the Permian sandstone. It is the result of wave and current action. There is evidently a bank of this sand lying against the foot of Muncaster Fell, which has been scarped by the river Esk. The general form can be well seen from Eskdale Green. Rabbit burrows show that this sand, with Permian sandstone pebbles, extends to at least 140 feet above O. D. Similar sand may be seen on the opposite side of the valley on the road to Muncaster (No. 11).

Perched Blocks and Moraines.

Scattered over the mountains, angular perched blocks of granite may be seen, evidently the last records of the Glacial period in this district. In ascending the footpath from Miterdale to Wasdale at a level of 700 feet above O. D., I noticed a perched block of granite balanced in a remarkable manner on its thinnest edge on granite *in situ*. It measured 18 feet high by 10 feet and 15 feet, on the sides. It was evidently kept in position by slightly leaning on the lower part against the rubbish of the mountain side.

Above Boot, by the bridge over the Esk, on the way to Hardknott, moraines of gravel and boulders may be seen. They are well developed for a considerable distance up the valley above the bridge, and have been scarped in several places by the river, which has evidently effected considerable denudation since the glaciers died out. Upon these moraines are to be seen, here and there, large blocks from the Volcanic series. One of two, by the bridge, measured 8 feet by 6 feet by 5 feet, and lay at a level of about 275 feet above

O. D., the moraine rising 20 feet above this. On the opposite side (left bank) there is a well developed terminal moraine truncated by the river, and upon it at a level of 345 feet above O. D. lay another Volcanic block 10 feet by 8 feet by 5 feet.

A large quantity of morainic matter lies at the foot of Wast Water, and may be well seen while descending the footpath from Miterdale. I believe it to be a terminal moraine, but it has no doubt been laid down in water, as a section in a gravel-pit at the junction of the road to Strand shows a laminated book-leaf clay of a hematite-red colour, intercalated between a hard clayey buff Till and a current-bedded stony Till. The basin of Wast Water seems peculiarly free from Drift.

Part II.

Early Glacial Conditions.

The Glacial history of this district commences with an accumulation of snow, which increased until it covered the whole of the mountains and valleys of Cumberland, giving birth to glaciers of considerable dimensions. My observations in other places have led me to believe that the land at this time stood at a much higher level relatively to the sea than at present, and that the Irish Sea was non-existant. Although the evidences of this are not, in my opinion, as complete as are the records of later phases of the Glacial period, they are important. A system of Pre-Glacial valleys[1] exists, and can, in fact, be traced in the Mersey and the Dee, and other rivers of the north-west of England, which could not have been excavated under present conditions of level. Again, there are no signs in any of the excavations made in connexion with sea works, docks, and rivers of the existence of beds holding a fauna older than that of the Glacial period. It is not, however, of this period I propose to treat, as I do not consider my observations in Eskdale throw any new light upon it.

Dispersion of Eskdale Granite.

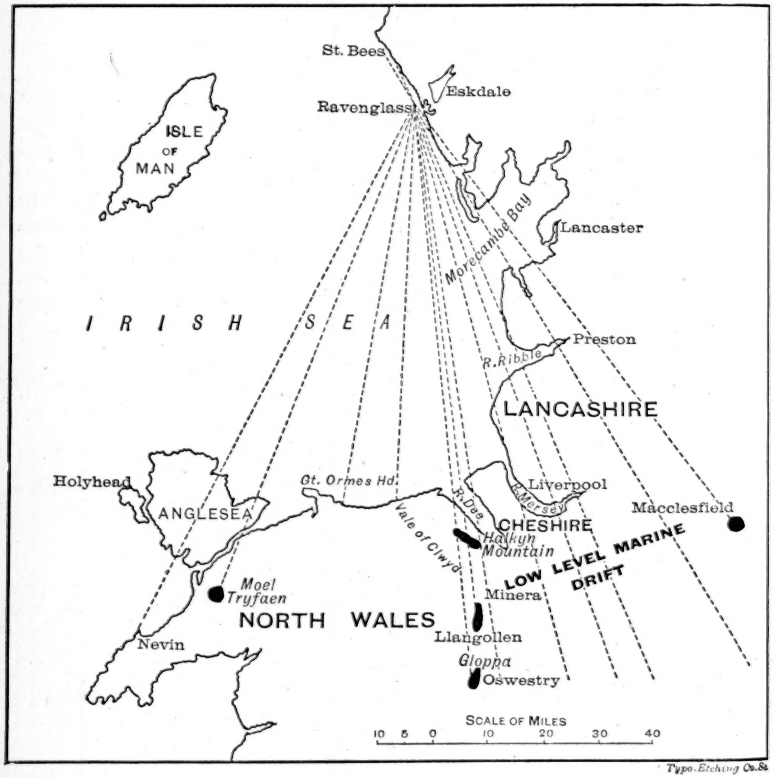
To any one like myself who has seen boulders and pebbles of Eskdale granite in the Drift dispersed over hundreds of square miles of country far away from its origin and associated with evidences of intense glacial action, it is very striking to notice in the birth-place of the boulders so few signs of glacial action on the rock itself. It is true that rounded contours are to be observed on many of the granite bosses, but as a rule the surface of the granite is singularly jagged even under the Drift. The rock appears to have been torn up and dislodged in consequence of the system of jointing, in cubical masses, which have not been pushed along in the till upon certain planes but have rolled over and constantly changed their positions. The rock is also incapable of receiving fine striæ and indents.[2]

[1] Buried Valley of the Mersey. Proc. Liverpool Geol. Soc. 1872–73, pp. 42–65.

[2] Griesbach says that he entirely failed to discover glacial scratches in the moraines at the end of the Himalayan Glaciers. (Mem. Geol. Survey of India, vol. xxiii.)

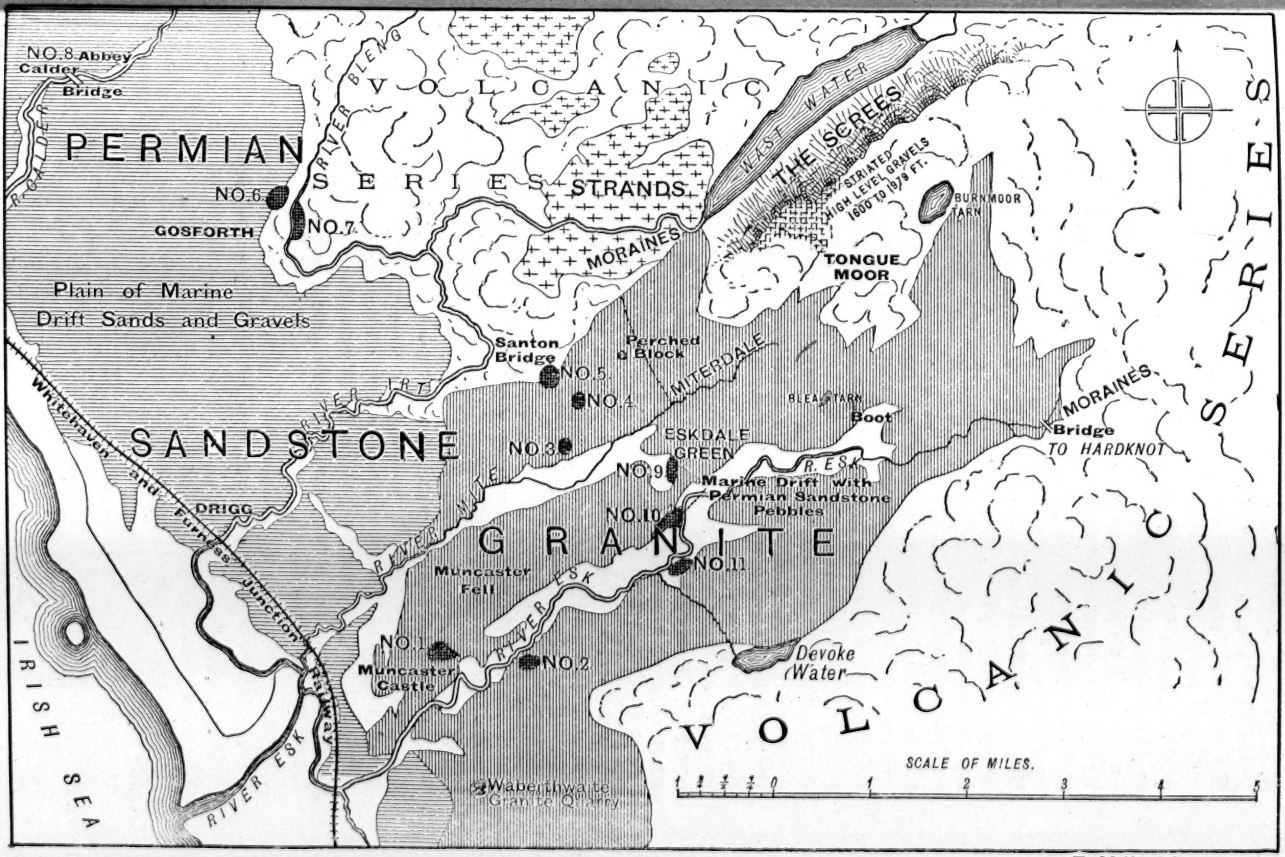
It is very instructive to contrast the effect of glaciation on the fine-grained rocks of the Volcanic series, which are found among the granite boulders with the granite. These stones are often flat, also due to a prevalent system of joints, and these plane surfaces have been polished smooth and covered with fine striæ.

The shape of the stone as well as its nature evidently influences the mode of glaciation. Some irregularly shaped stones are covered with the most extraordinarily confused intersecting scratches. That the granite boulders have been brought down the valleys by glacial ice notwithstanding the facts stated admits of no doubt; but in what way they have been dispersed south, west, east, and even north in view of the ideas put forth by the new school of glacialists is a question worth examining. In the accompanying Map, Fig. 2, the distribution of these erratics is roughly shown, the dotted lines exhibiting the direct course from the point of origin, not the actual course travelled, which cannot be known.



T. Mellard Reade, del.

FIG. II.—Map showing dispersion of Eskdale Granite.



T. Mellard Reade.

FIG. I.—MAP SHOWING RELATIONS OF ESKDALE DRIFT TO THE COUNTRY ROCKS.

Has the Carriage been by Land-ice?

It will be seen that the lines of travel between Carnarvonshire and Macclesfield diverge at an angle of 66 degrees, and between Macclesfield and St. Bees they sweep through as much as 180 degrees. The question arises if these fragments of the parent rock have travelled to their several localities by means of land-ice, as asserted very positively by the new school of glacialists, what sort of internal flow and movement of the ice does this involve? According to the well-known axiom of geology we must explain geological phenomena by reference to natural agencies now to be observed in action. If this cannot be done by exact parallel we must appeal to some well known principles of physics to help us out. We must show that the conditions differ and in what way and to what extent.

The only knowledge we possess of the nature of the movement of land-ice is that in the form of glaciers in mountain districts. A glacier, such as it is assumed filled the Irish Sea, unless we can point out good grounds to the contrary, must be considered to march along on the same general principles as those glaciers we are acquainted with having steeper gradients. Any one who has seen a glacier, or the photograph of a glacier, will have observed that the material dropped upon its surface from abutting cliffs and also that which joins it from tributaries retains as definite and distinct an existence as a tramline in a main highway. This fact may be observed in every Alpine glacier, and it needs only a glance at the admirable photographs of the glaciers of the Central Himalayas given by Griesbach[1] to tell us that the same holds good in Asia. If, therefore, we are to consider that an ice-sheet made up of confluent glaciers acts differently and disperses throughout its mass, the stones taken up at one point distributing them generally and regularly over an immense area instead of in trains, the onus of proof lies on those who believe such to be possible. Personally I consider it to be a mechanical impossibility. Glacial ice moves along lines of least resistance, and these lines within certain limits, and under common conditions, are approximately parallel. A glacier from Eskdale, joining a main stream of ice from Scotland along the Irish Sea, would have its burden taken in train and deposited on a definite line, not distributed through the moving river of ice. We should find the probable record of its line of travel in the Drift itself.

Phenomena of distribution points to Water Carriage.

But why should we go out of our way to displace the Irish Sea with land-ice to provide transport for our dispersed blocks? The evidence that the bulk of the Drift of the plains, and much of the high-level Drift, is sea-bottom, whether in place or displaced, is so strong that no one attempts to gainsay it. Water carriage provides the very thing that is wanted to explain the dispersal of Eskdale granite boulders. Unlike the movement of ice, the sea is

[1] Mem. Geol. Survey of India, vol. xxiii.

subject to flux and reflux twice a day to consequent change of current for every hour of the day. Its surface, and anything floating thereon, is affected by winds, changeable, but having a more or less prevalence of direction.

All the conditions necessary to satisfy the problem of boulder distribution are here, if we add floating ice; but the explanation so close at hand, and so complete, is thrown aside, ostensibly because it involves submergence of the land to a greater or less extent.

What Marine Drift in Eskdale tells us.

As I have shown in the preceding pages, Marine Drift is found in Eskdale and Miterdale up to a level of 400 feet above the sea. This Drift is similar to, and the equivalent of, the Marine Drifts found up to the same level on the coast of North Wales. The supporters of the Irish Sea glacier hypothesis contend that these sands, gravels, and clays, together with similar Drift at higher levels on Moel Tryfaen, Halkin Mountain, between Minera and Llangollen, and on Gloppa, have been pushed up in opposition to the local Snowdonian and North Wales glaciers by the hypothetical Irish Sea glacier after traversing the sea bottom. This explanation will not, however, account for the presence of Marine Drift in Eskdale and Miterdale.

The Permian sandstone-pebbles found up to a level of 320 feet above O. D. could not have been pushed up by land-ice from the Irish Sea against the general flow of the valley-ice. The ice-sheet bearing down from Scotland would have had to turn sharp round at right angles and flow up Eskdale to have effected this. If such an extraordinary thing did happen, in what way, we may ask, have Lake District rocks got conveyed to the Isle of Man,[1] or how have Eskdale granite boulders and pebbles been carried north-westerly in direct opposition to the hypothetical ice-flow, as far as St. Bees? Test it in any way we may the ice-sheet explanation breaks down here.

Extent of the Submergence.

Although in this district I observed no evidence of submergence higher than 400 feet above mean sea level, it must not be inferred that that was its maximum limit.[2] It would take a very careful survey of a much larger area of the Lake District to offer an opinion worth having as to the extent of the maximum submergence. The glaciated gravels at the top of Screes, Wast Water, and down to a level of 1300 feet above the sea are of an altogether different type to the marine gravels of Eskdale, and appear to be a purely glacial

[1] "There is abundant evidence too of a strange intermingling of foreign rocks in the till, *which must have travelled from the coast of Cumberland* (the italics are mine), the South of Scotland and the North of Ireland" (Sketch of the Geology of the Isle of Man—Horne—Trans. of Edinburgh Geol. Soc. vol. ii. part iii. 1874).

[2] The late Mr. Clifton Ward (Geology of the Northern Part of the English Lake District, Mem. Geol. Survey) considered there were evidences of very great submergence, but as I have not visited the localities he names, and am not clear as to the grounds on which he judged the Drifts he mentions to be Marine, I cannot use his observations.

product, and considering that they extend to the very edge of this great scarp, a very interesting one too.

Conclusion.

There are many more interesting problems connected with the extent and distribution of Eskdale Drift, such as the vertical amount of denudation which the granite area suffered during the Glacial period, the length of this period, and the extent of time which has elapsed since its close. To all these questions the Glacial geology of Eskdale and Wastdale might, I think, be made to yield some more or less certain answers. I will not, however, peril the simple object of this paper by discussing such recondite problems. The object of my investigation was to test the bearings of the Glacial phenomena of Eskdale upon the current theories of glaciation, and this done I must for the present conclude.

IV.—The True Horizon of the Mammoth.

The Foreign Evidence and General Conclusion.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.G.S., etc.

In previous communications to the Geological Magazine I have subjected the evidence as to the age of the Mammoth in the British Islands to criticism, and I ventured to conclude that wherever we can find the remains of the Mammoth and its contemporaries undisturbed and *in situ*, these remains are found under and not over or in the drift. This, so far as I know, is the case in every recorded instance where the Mammoth beds and the drift have been found superimposed upon each other.[1] Let us now turn to the Continent and test the problem there. If we are to test it in the same way, which I take to be the only satisfactory way, namely, by evidence of superposition, we must naturally limit our survey to countries where the drift actually occurs. First, let us turn to Switzerland.

Whenever the sequence has been actually ascertained, that is to say, ascertained by one set of deposits being superimposed on the other, it seems to me that the beds with quaternary mammals, in Switzerland, always underlie the erratic beds. Thus, a skull of the Mammoth was found, in 1841, four kilometres from Rapperschwyl, in the Canton of St. Gallen. According to the section published by Escher von der Linth and C. Martins, the beds in this case lay in the following order :

1. Black and angular fragments of glacial origin.
2. Rounded pebbles and boulders, sometimes as big as a man's head, like those in the Nagelfluh.
3. Bluish and yellowish clays.
4. Bituminous remains of wood mixed with sand and clay.
5. The Mammoth's skull in question.

[1] I overlooked the very important and notable case at Selsea, where the Mammalian bed is overlain by a deposit with boulders and greywethers.

6. Greyish clay and fine sand, containing *Planorbis, Paludina,* and *Cyclas.*
7. Molasse and Nagelfluh of Tertiary age.[1]

This is a very good example, and it seems to be very conclusive.

According to the same authors, bones of the Mammoth have been found by M. Miollet, in the valleys of the Jura at Neuchatel, in a thin stratum of diluvium gravel, composed of Jurassic and Tertiary pebbles, and covered by glacial débris, consisting entirely of Alpine rocks.[2]

Let us now turn to the famous lignites at Dürnten and at Utznach, near Zurich, upon which so much has been written. It has been often said, on the authority of Professor Heer, that the beds in question are intercalated between beds of drift. Heer, however, writes most guardedly on this subject. "In Eastern Switzerland," he says, "until recently the upper erratic formation only was known which overlies the stratified pebble beds. At Utznach, in a section on the road to Gausen, now again covered up, Prof. A. Escher von der Linth saw quite distinctly the direct superposition of the lignite formation upon the Miocene beds; so that at least, at this point, there were no traces of erratic blocks to be seen between the Miocene beds and the lignites. At Dürnten also, the clays under the lignite formation only contained such stones as may have been derived from the conglomerates of the surrounding hills. The hypothesis of two Glacial periods does not, therefore, seem to be supported by the facts observed in Eastern Switzerland." The same views are maintained by Sir Charles Lyell. He visited the beds at Utznach in company with M. Escher von der Linth, and those at Dürnten with Professor Heer and M. Marcou. "The beds in both places," he says, "are of the same age. At Utznach the lignite beds rest directly, but unconformably, on highly inclined, and sometimes vertical, Miocene molasse, and are covered with gravels, and these again with erratic blocks," and he distinctly says that the evidence is wanting at Utznach to establish their interglacial character.

In regard to the deposits at Dürnten, M. Charles Grad, who examined them with great care, found the underlying beds to consist of light-coloured clays or marls, such as occur in freshwater beds in lakes and marshes. These marls contain numerous rolled pebbles, but M. Grad says, "je n'y ai pas remarqué de stries glaciaires."

It would seem, therefore, that so far as the beds at Dürnten and Utznach are concerned, the evidence is against their being underlaid by any drift deposits, and confirms the British evidence. We are told, however, that a different conclusion must be drawn from a similar bed occurring at Wetzikon, near Dürnten (in which the plants were exactly similar to those at Dürnten, and which is doubtless of the same age), and that there Alpine blocks had been found underneath the lignite. The evidence about it, however, is very unsatisfactory. In the first place, Heer speaks of

[1] See Bull. Soc. Geol. de France, 2nd ser. vol. vii. 1858, p. 601.
[2] *Id.* 602.

this lignite bed as of small extent. In the next place, it is unfortunate that this particular and most important section should have been entirely covered up, and be no longer available for study. It is also unfortunate that it should have been an artificial and not a natural section. Mortillet has pointed out that such sections made by workmen, and not under the eye of scientific men, are very unsatisfactory. Speaking of this very section, he tells us how easy it is in deep pits through soft strata, to have a slipping of positions of the beds. M. Charles Grad, again, in discussing it, says that it was much disturbed. He had himself noticed a streak of gravel traversing the lignite; in another place the same lignite was penetrated by a wedge of clay. In some places it rested in small pockets on the gravel and the clay, in others it was standing vertically, and merely covered by vegetable soil. "These circumstances point," he says, "to slipping or crushing of the lignite beds after they were formed." This description, by one who examined it, and the conclusion forced upon him, surely destroy the whole value of the section as a crucial and critical test, and, as Mortillet suggests, it points to the supposed subjacent Glacial beds, having been accidentally, and not naturally, so placed.

The stratigraphical evidence of the lignites we have described is completely at one with that of the animal remains found in them. These do not consist of the Mammoth and the Woolly Rhinoceros, but of the *E. antiquus* and *R. leptorhinus*, the same beasts found in the Forest Bed, which is at an earlier horizon than that where the Mammoth occurs, and *à fortiori* one more unlikely to occur among true glacial beds, and which is in front overlain by them. Neumayr, in his "Erdgeschichte," says that similar remains occur in the beds at St. Jacob, on the Biros, near Basle; in the Algau, near Somthofen; at Chambery and Sonnaz, in Savoy; and at Leffe and Val Gandino, in Upper Italy; in none of which places is the bed in which they occur intercalated between glacial beds.

M. Favre, in his paper on the beds in the neighbourhood of Geneva, says distinctly that the glacial beds with their erratics, which are greatly developed there, are superimposed on the so-called "alluvion ancienne," *i.e.* the stratum in which the Pleistocene animals occur; and he adds, "Nous n'avons pu découvrir dans les environs de Genève aucune preuve de l'existence de deux epoques glaciaires."[1]

At Chambery in Savoy, some lignites have occurred in which although no Mammalian remains have been found, plant remains occur, showing them to be on the same horizon as the lignites of Dürnten and Utznach. Their age, says Mortillet, is perfectly established, they are anterior to the great extension of glaciers, whose products, clays, striated pebbles and erratic blocks overlie them. Mortillet continues thus: "Le lignite de Chambéry est tout à fait analogue, comme constitution et aspect physique, à celui des Cantons de Zurich et de St. Gall. Le gisement est semblable et tous les deux sont pré-glaciaires."[2]

[1] Bull. Soc. Geol. de France, ser. iii. vol. iii. pp. 659–660.
[2] Le Préhistorique, pp. 216, 217.

M. Mortillet discusses another instance of which much has been made, and which is a good example of the slight basis upon which interglacial theories have been built. This is an alleged intercalation of stratified "ancienne alluvion" between two glacial beds, in the gorge of the Drance, near Thonon (Haute Savoie). M. Mortillet says the Drance there cuts through some almost vertical calcareous beds; on the upturned edges of these beds there rest layers of alluvion, over which lie glacial beds. In some places in the gorge the calcareous beds have been denuded of their covering, and form a cornice; on to this cornice some of the glacial débris has slid down and made a kind of talus, looking at first sight as if it were overlain by the alluvion. The fallacy of this reading was tested by M. Mortillet, by making excavations on the spot,[1] when it turned out that there was no intercalation whatever, but that the alluvion lay always underneath the glacial beds.

If we turn from the northern to the southern flanks of the Alps we shall find precisely the same evidence. At Careguano, at Lanzo, near Stura, at Giffenga in the Valley of the Cervo, at Boca, at Maggiora and at Leffe (Gandino), there are certain lignites which are distinctly correlated by their Mammalian remains and other contents with the lignites of Utznach, Wetzikon, etc. Now it is a remarkable fact, as Gastaldi has shown, that these Italian beds rest directly upon Pliocene deposits and in no case, so far as it is known, do they have any glacial beds below them. The facts here quoted about North Italy have proved a stumbling block to Prof. James Geikie, who admits them, and admits that there are no traces in North Italy of former oscillations of climate (Geol Mag. 1872, Vol. IX. p. 256). He calls in that modern *deus ex machina* denudation to explain it. It seems to me very plain, therefore, that in the Alpine regions of Switzerland and its neighbourhood, the evidence shows that the Mammalian beds do not overlie the Drift, but when they occur together they are always covered by them.

Let us now turn elsewhere. In the valley of the Inn, above Innsbruck at a place called Hötting, there is a breccia composed of stones from the Upper Triassic dolomite, of pieces of red sandstone, and of crystallized rock. This breccia contains remains of plant. Penck and others have declared this breccia to be underlaid as well as overlaid by moraine matter of glacial age, and the particular instance has been made much of by the advocates of interglacial mild periods. Unger and Stur, who have examined the plant remains, have found among them leaves of fan palms and other evidences of a tropical climate, proving the beds to be of Tertiary age, and therefore outside the possibilities of being interglacial. I feel convinced that in other cases where the drift has been supposed to underlie the Pleistocene land-surface that Tertiary conglomerates more or less disintegrated have been mistaken for it. The conclusion for which I am arguing is also supported by the evidence from the valley of the Rhone. Falsan, a most competent authority, writes as follows: "Durant nos études avec M. E. Chantre sur le terrain erratique du

[1] Le Préhistorique, p. 312.

basin du Rhone dans sa partie moyenne nous n'avons pas trouvé de traces de deux ou de plusieurs periodes glaciaires. . . . Nous avons été amené aussi à accepter qu'une seule période glaciaire d'une durée immense," and after granting certain oscillations he continues:—"Nous repoussons comme peu vraisemblable la theorie des récurrences de periodes glaciaires distinctes."

In regard to the Cavern of Chaleux on the Meuse, M. E. Dupont writes that the remains of man were deposited before the deposition of the yellow clay with angular blocks of limestone and the deposition of the Loess (Q.J.G.S. vol. xxiii. Translations and Notices, 3 and 4).

If we turn to North Germany we have an area where the facts are, as Mr. Geikie says, very difficult to read, from the very mixed contents of the beds, from the absence of natural sections, and from the absence also of true Till or Boulder-clay. The great mass of the drift beds consists of sand, which is not always easy to distinguish from the sands of the Brown Coal-formation. It is also very probable that in every case the Mammalian bones found in them are not *rémanié*. In regard to the shells, this is certainly so, for as Prof. Geikie says, they are not only much broken and abraided, but they are sometimes filled with a material entirely different from the matrix in which they are embedded, showing they are merely erratics, like the glaciated stones among which they occur.

A test of the difficulty of correctly reaching these North German beds may be gathered from the fact that some distinguished geologists, notably the Commission appointed by the National Geological Institute of Prussia, have quoted certain turf deposits in Lauenburg as evidence of an interglacial mild period. These beds were asserted by Keilback, in 1884 to be interstratified among glacial beds. They have recently been carefully examined by Credner, Gedinitz, and Waanschaffe, who have shown that the bed of turf in question is not intercalated as was supposed, but lies on the glacial beds. Movements of the soil and slippings have misled Keilback; for, where the section can be examined in tact, it shows a layer of marine sand containing a *Cardium* which previous observers have treated as of diluvian age, but which really belongs to the Miocene period, above which rests a calcareous sand which is truly diluvian, and then the glacial marl. Above this rests the turf, containing lines of sand, above which there is no glacial bed whatever, and the turf with its sandy streaks everywhere overlies the glacial bed. The plants it contains are all still found in Lauenburg and the bed is really post-Glacial.

Turning to Scandinavia, the evidence is very scanty indeed. I know of only one case which is germane to our discussion. Peat, with palæolithic implements, and bones of the cave bear, is described by Nillsson as underlying the Jära wall, a great ridge of sea-gravel extending along the coast of the Baltic from Ystad to the part between Trelleborg and Falsterbo. "If this ridge be an åsar," says Mr. Geikie, "as from the description may be inferred, and should it prove to belong to the great åsar series, this would demonstrate that man had inhabited Sweden before the last great submergence

and period of floating ice" (Geikie, GEOL. MAG. 1872, Vol. IX. pp. 259 and 260).

In regard to Russia, Pander detected remains of Mammoth and Rhinoceros in reddish clay, covered by erratic blocks, eight versts to the south of Verchni Volotchok. . . . . In one spot, 300 versts south of St. Petersburgh, and twenty versts south of the river Kolomenba, M. Pander further found the horns of a Stag in gravel or drift, 21 feet below the surface, and covered by fine yellow sand, which is surmounted by clay and northern erratic blocks (Russia and the Ural Mountains, vol. i. p. 651*, postcript).

Sir Roderick Murchison himself has recorded the discovery of the bones of the Mammoth and Woolly Rhinoceros, near Moscow, in reddish clay, covered with erratic blocks, on the plains thirteen miles distant from the river (*Id.* 650). "If we follow," says Belt, "the northern drift southwards from Moscow, as I have done, we find it gradually changes from clay with boulders to the clay without boulders that covers the southern plains. Around the Sea of Azof, cliffs of this Glacial clay, 100 feet high, can be followed continuously for miles, and its junction below with the older beds is sharply defined. It rests on a freshwater deposit containing shells of species of *Unio*, *Cyclas*, and *Paludina*, and at this horizon fragments of the tusks and bones of the Mammoth are abundant, and are always undoubtedly older than the Glacial clay. In a similar position the same remains have been found at Odessa and other places in the south of Russia" (Belt, Quarterly Journal of Science, vol. vi. p. 290).

This survey of the European evidence does not profess to be exhaustive, but it includes, I believe, all the important examples upon which the theory of the post-Glacial or inter-Glacial existence of the Mammoth has been based. It seems to me that that theory, as tested by the European evidence, will not bear criticism, and that when Geoffrey St. Hilaire gave the Mammoth the name of *Dicyclotherium*, he was postulating for it, as many others have done since, a character which the evidence does not support.

Let us now shortly turn to America. In America the evidence seems to me to be very contradictory. The great deposits of bones contained in the so-called Salt-licks are outside the area occupied by the drift. Within the drift area most of the remains occur as sporadic bones, and they must be treated as erratics just as the tree trunks and logs which have been frequently found there imbedded in tough boulder-clay. When we come to test the problem, however, in the only adequate way, namely, by an actual undisturbed land surface of the Mammoth age containing bones, the evidence is very fragile and unsatisfactory. That the so-called dirt-beds and Forest-beds are covered by Till and in many cases by an enormous depth of Drift deposits is universally admitted. That so far as we know, they never occur at or near the surface except either outside the Drift area or where it has thinned itself almost out is also admitted. That above the true dirt-bed there very often occur logs and detached pieces of the bed which have been denuded and

detached from it and which are found like boulders in the clay, sometimes such portions being several yards in size, is also true, but I have failed to find evidence of a Drift-bed underlying a dirt-bed *in situ*.

The very great majority of cases known, depend on such unsatisfactory evidence as well-sections. It is not wonderful, therefore, that there should be a feud among the American geologists as to the reading of the facts. The State geologists of Indiana recognize only one forest-bed, and declare that it *underlies* the Drift.

In Illinois the evidence is most unsatisfactory. I will give one of the most typical cases relied upon by Professor Geikie in his defence of interglacial beds. "In Perry County, Illinois, Mr. Worthen describes a bed of blue sand with leaves and sticks as occurring below the main mass of Drift. *This bed, he continues, usually lies at the bottom of the Drift deposits, but at one point in Jackson County* it was underlaid by *a bed of sand* two or three feet in thickness." It is assuredly a brave thing to postulate that the occurrence of a bed of sand is in itself evidence of the dirt-bed being underlaid by Drift. In Woodford County a similar accumulation of peaty matter was found at a depth of about 65 feet below 50 feet of *hard-pan*. In Ohio, Mr. Charles Whittlesea tells us how he had examined 59 wells in 1844, of which only six, or 10 per cent., showed traces of dirt-beds, leaves, timber, or silt. While he names several instances of logs of wood being found imbedded in the till, I cannot find any case where dirt-beds are stated by him to have been underlain by Drift, while all are stated to have been covered by deep beds of Drift.

Dr. Wright, "who has written so admirably on the glacial age in America, says a thorough study of the condition and distribution of the buried forests, bears strongly, as I cannot but think, against the complete separation of glacial epochs in North America."

Mr. C. R. Gilbert, a distinguished American geologist, says: "In America, where there is great activity in the investigation of glacial phenomena the evidence of a single interglacial period is cumulative and overwhelming, while there is no indication whatever of more than one." The American case as thus summed up is consequently completely at one with the European one; and it must be allowed, I think, that if there be here and there cases which appear to point to a different conclusion they are distinctly sporadic exceptions to a widespread law, and as such ought to be sifted and criticised with the greatest care and completeness, and that it is for those who still maintain a post-Glacial or inter-Glacial existence of the Mammoth to prove their case.

I have here and elsewhere in these papers used the words post-Glacial and inter-Glacial in their commonly accepted sense, as meaning that the Mammoth lived after the deposition of the Drift or lived between two such successive depositions. When I say that the facts inevitably point to the Mammoth beds when *in situ* always underlying the Drift, I do not mean that the Mammoth preceded the so-called Glacial age. I have written a very big book to try and show that it is contrary to the physical qualities of ice to suppose

that it can move except under the influence of gravity, and that the theory of the distribution of the Drift deposits over hundreds of miles of level country by ice sheets is an hypothesis unsupported by experiment and at issue with the laws of ice movement so far as they are known. I do not believe, therefore, that the great sheets of gravel, clay, and sand, and the erratics connected with them were distributed, or can have been distributed by ice. I believe with the Fathers and Grandfathers of Geology, my Masters Murchison and Sedgwick, Hopkins and Phillips and Conybeare, Von Buch and D'Archiac, that the Drift, as we find it, was very largely distributed by water and not by ice; and when we find the Mammoth beds overlain by Drift, it means in my view not that the Mammoth lived before the so-called Glacial age, but that it lived before the diluvial movement which distributed the Drift, and which I think I have proved, in my work on "The Mammoth and the Flood," exterminated that beast and some of its contemporaries.

In my view the Glacial age was not an age of ice caps and ice domes and portentous ice sheets, nor of any other transcendental nightmares, but an age of big glaciers occupying the mountain regions of half the northern hemisphere, and perhaps of all the southern one in the temperate zones. Alongside these glaciers there then existed, as there exist still in New Zealand, stretches of fertile country where the Mammoth and the Rhinoceros could live, where the oak and the fir could grow, where the contrasts of climate were not caused by difference of latitude, but by difference of elevation, and where, therefore, the Hyæna might well feed upon the Reindeer, as we know positively it did, where the Musk Sheep and the Pika could live along side of the Tiger and the gigantic Ox, as we know they did, and the polar willow could live upon the upper banks of a river whose lower one were occupied by the fig and the Canary laurel. The facts to be explained seem, to me, to inexorably demand this.

Professor Geikie, and other champions of extreme Glacial views, are willing to allow that the Mammoth lived in Siberia while the ice dominated Europe and North-Eastern America; I believe that it not only lived in Siberia, but in European Russia, in Northern and Central Germany, in France, and in South Britain, while the Mammoth and the Mastodon occupied very much the same country as the Buffalo did in later times in America. At the same time, Snowdon and the Grampians, the Vosges east of the Jura, and the Laurentian uplands, nourished large glaciers, while those of Norway and Switzerland, and the Cascade mountains, were much larger than any now to be found in those countries. Then came a great catastrophe, caused in all probability by the upheaval of some of the greatest mountain-chains of the world, of which I have published a great deal of evidence in these pages, and of corresponding subsidences elsewhere, about which I may perhaps be allowed to write on another occasion, and the direct result of this was the diluvial movement I have mentioned.

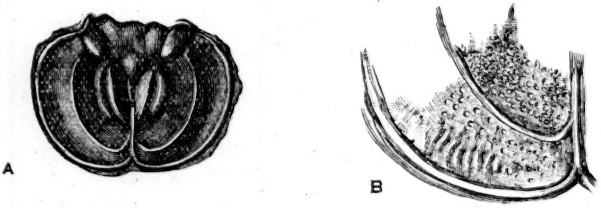
The story here condensed is, I believe, a logical story, and it is the only one which, so far as I know, explains the facts.

V.—Note on a new British species of *Cyclus* from the Coal-measures of Bacup, Lancashire.

By Henry Woodward, LL.D., F.R.S., F.G.S.

Some years since, Mr. Mark Stirrup, F.G.S., of High Thorn, Bowdon, Cheshire, placed in my hands a new form of *Cyclus* for examination. I had a drawing of it prepared, and made a note of it for future reference, but proceeded no further. That specimen is now in the Museum of the Owens College, Manchester, and by the kindness of Mr. W. E. Hoyle, the Keeper of the Collections, I am permitted to describe it in the Geological Magazine.

The specimen was obtained by Mr. George Scott, from the "Gannister seam" of the Lower Coal-measures, Old Clough Colliery, Bacup, Lancashire, and shows the dorsal aspect of a small circular Crustacean (?) shield, about the size of a shilling, a figure of which is subjoined. (The ventral aspect adheres firmly to the matrix, and cannot be described.)



Cyclus Scotti, H. Woodw., sp. nov., Lower Coal-measures, Bacup, Lancashire.
A. Dorsal aspect of carapace (nat. size).
B. A portion of the left posterior border magnified to show ornamentation.

Specific description.—Shield, or carapace, nearly circular in outline, bilaterally symmetrical (25 millimètres broad by 20 mm. long), having a well-marked median ridge dividing the carapace in half for 8 mm. from the posterior border; posterior margin slightly indented or notched in the centre; the lateral and posterior margins of the shield encircled by a smooth raised rim, which stops short at the antero-lateral margin (which is slightly compressed where the rim terminates), the shield being truncated for a breadth of 12 mm. in front. There is evidence on the right side of a slight extension of the smooth margin of the shield extending beyond the outer raised rim. Anteriorly the shield is ornamented by four, nearly equal, oval, prominences, each being about 5 mm. long, placed two on either side of the central line,[1] with their longer axis directed towards the front of the shield; a well-marked, smooth, semicircular ridge occupies the centre of each lateral area, and unites with the raised median ridge near the posterior border of the shield.

The area enclosed between the outer and median ridges becomes considerably narrower as these approach the centre, near the posterior region of the carapace. The median ridge ends in front close to the outer pair of oval prominences; two other rather

[1] The two inner oval prominences have been *largely cut away* at some time in an injudicious attempt to develop the anterior part of the carapace.

semicircular smooth raised ridges, broader and shorter than the preceding ridge (by which indeed they are encircled), occupy the inner and more central portion of the shield, the outer one commencing near to, and the inner one on, the central ridge, at 5 mm. distance from the posterior border, and curving forwards until they touch the posterior ends of the two pairs of oval prominences near the front of the carapace. In the centre, between these raised ridges and the oval bodies, is a small lozenge-shaped area, which is continued backwards till it unites with the median ridge of the shield.

The surface of the shield (particularly the posterior portion) is very finely granulated with minute circular and oval pustules (see woodcut, fig. B). No eye-spots are observable (unless a pair of the oval prominences in front may represent eyes? see woodcut, fig. A).

There is no trace of any appendages to be discovered on the matrix.

Observations.—Of the seven species of *Cyclus* already described by me, six are from the Carboniferous Limestone of Yorkshire and Ireland (see GEOL. MAG. 1870, Vol. VII. pp. 554–558, Plate XXIII.) and one from the Coal-Shales of Carluke, Scotland (see Brit. Assoc. Reports, 1868, p. 72, pl. ii. fig. 1, and *op. cit.*). Several specimens, not yet described, were obtained, many years since, from the pennystone ironstone, over the thick coal, of the Staffordshire Coal-field, at Coseley, near Dudley, by the late Mr. Henry Johnson, C.E., F.G.S., of Dudley, and will be shortly described by me.[1]

In general outline this species from Bacup resembles most nearly *Cyclus* (*Halicyne*?) *agnotus*, H. von Meyer, sp., from the Muschelkalk of Rottweil, Germany (see Palaeontographica, 1847, vol. i. p. 234, pl. 19, fig. 23), but it differs in having an indentation or notch in the posterior border, whereas the German specimen has a small prominence. The arrangement of the ornamentation of the shield is similar but still very distinct.

I have therefore no hesitation in treating this as a new species, and have named it *Cyclus Scotti*, after its discoverer, Mr. Geo. Scott, by whom it was presented some years ago to the Owens College Museum.

VI.—On the Occurrence of a Trilobite in the Skiddaw Slates of the Isle of Man.

By Herbert Bolton,
Assistant Keeper, Manchester Museum, Owens College.

THE series of slates, schists, and grits, of the Isle of Man, which are regarded as identical with the Skiddaw Slates of the Lake District, have hitherto yielded no traces of fossils, if we except the rare worm-like markings known as Palæochorda. The writer during the month of August last, took the opportunity of a visit to the island (in connection with the geological mapping by Professor Dawkins) to search very closely the least altered slates of the series along their northern outcrop.

After a barren search of several days, two specimens of Palæochorda and the fragmentary intaglio cast of a trilobite were found.

The specimens of Palæochorda call for no special mention, but the

[1] I regret to have overlooked Mr. B. N. Peach's paper on *Cyclus testudo*, Carboniferous series, Langholm. (See Trans. Roy. Soc. Edinb. 1883, vol. xxx. pl. xxviii. figs. 9–9*d*, p. 227.—H.W.

trilobite cast, notwithstanding its fragmentary condition, is of great importance, as giving a possible clue to the stratigraphical position of the slates in which it occurred, and also as demonstrating the existence of organic remains in what was formerly regarded as an unfossiliferous series.

The specimen was found at Ballastowel, a hill crest overlooking Ramsey on the south-west, and lying midway between the familiar Albert Tower and Elfin Glen.

The Skiddaw Slates are here found dipping at an angle of about 45° to the north-west, and are a little contorted. They consist of an alternation of schistose slates, dark and but slightly altered slates and dark slates charged with well rounded quartzite pebbles.

Quartz veins pass in all directions through the series.

The trilobite cast was picked up from the scree immediately under the schistose slate and was evidently derived from that rock.

The following diagnosis of the trilobite has been obtained by the examination of a wax impression.

Impression of Body and Pygidium.

Thorax of six rings; axis convex and of uniform width; body rings narrow and well marked off from one another. Pleuræ very broad, twice the width of the axis; grooves deep, broadening towards the extremities, and disappearing a short distance from the axis; extremities directed backwards. Pygidium a little more than half the length of the thorax; width double the length; axis flattened, convex, and ending bluntly in the middle of the pygidium.

Observations.—From the presence of six thoracic rings, grooved pleuræ, and semi-circular smooth pygidium with feeble axis; the writer was inclined to class the specimen as an Æglina, but Dr. Henry Woodward has kindly pointed out that it differs from Æglina in the sides of the axis being parallel along their whole length, and in being convex, whereas in the former the axis diminishes in breadth from before backwards, and is flattened.

From a careful comparison of the specimen with others from the Cambrian of North Wales, Dr. Woodward is of opinion that it might with equal propriety be placed in the genus *Asaphus* as *Æglina*. Unfortunately the specimen is too distorted and fragmentary to settle the point. It is very probable that the specimen belongs to one of the two genera, and since both are markedly Ordovician or Lower Silurian forms, we may take it as evidence that the Skiddaw Slates in the vicinity of Ramsey, are of Arenig or Llandeilo age. This supposition is strengthened by the occurrence of two specimens of *Palæochorda* (an Arenig form) in the same beds.

The relation of the slates near Ramsey to the general series are difficult to determine until the mapping of the Island, now in hand by Prof. Dawkins, and the Geological Survey of Great Britain, is completed.

A traverse, however, made from Porth Mooar, the commencement of Messrs. Harkness and Nicholson's anticlinal,[1] to Ballastowel, a

[1] Harkness and Nicholson, Quart. Journ. Geol. Soc. vol. xxii. 1866.

distance of three miles, showed the slates dipping to the north-west at a high angle (about 45°), so that a considerable thickness of slate must underlie those which yielded the trilobite. The thickness also of the overlying slates must be considerable.

The finding of the interesting specimen which we have described, in the midst of the Skiddaw Slates of the Isle of Man, will, we trust, stimulate research and lead to increased attention being paid to these beds.

VII.—The Glacial Succession.

By R. M. Deeley, F.G.S.

ALL students of British Glacial geology must feel that to Prof. James Geikie we owe much of our present knowledge concerning the Pleistocene succession in Europe; for he has not only been a zealous worker in the field, but has placed before us in a clear manner the valuable investigations of Continental geologists, with a view to showing how the succession that has been made out on the main land may be made to agree with that of our islands.

In a paper read before the Royal Society of Edinburgh last May, "On the Glacial Succession in Europe," we have his latest important contribution to this subject. No doubt when we have the promised new edition of the "Great Ice Age" in our hands, giving in detail the facts upon which he bases his conclusions, we shall be better able to appreciate the points he raises in this paper. Still the succession he has adopted is so clearly described, that in the absence of his more complete work, and even though he has not referred specifically to English deposits, I may, perhaps, be allowed to compare his results with those I gave in a paper read before the Geological Society in 1886.

Many geologists even now seem to be far from having come to a decision as to whether there really was any considerable alternation of warm and cold epochs during the Pleistocene period, nor can it be said that there is more than a general agreement in many cases between the successions made out by workers in different districts. We must, therefore, be content at present to state the opinions at which we have individually arrived, and by comparing the results so obtained strive to construct a true history of the Pleistocene period. That this can be accomplished there seems to be no doubt whatever; but whether it can be arrived at by a fuller appreciation of the facts now at our disposal, or whether it will result from future discoveries, remains to be seen.

I trust that it will not be supposed that I wish to deal with Professor Geikie's conclusions in a captious spirit, or that I wish to adversely criticise his conclusions; my object is really to place on record what I regard as a possibly correct correlation of the succession he has adopted with the one made out by myself, and also to refer to certain physical changes which have an important bearing upon the question of the age and formation of certain high-level shelly gravels.

Of course it is possible that I may have misunderstood Professor

Geikie's correlation of the Scottish deposits with those of England and Wales, for it was not necessary for his purpose to give us any facts, other than such as relate to the distribution of the Boulder-clays, so we cannot with certainty decide as to which English deposits he is sometimes referring. Still, from the localities he mentions, I judge that the "lower or oldest" Boulder-clay which "has the widest extension southwards, for it has been traced as far as the valley of the Thames," must be the Chalky Boulder-clay—that is one of my Middle Pleistocene deposits. This view is supported by his statement that "The Upper Boulder-clay, on the other hand, does not extend south of the Midlands of England." He here seems to refer to the Purple Boulder-clay, which is possibly of Newer Pleistocene age.

On p. 146 of his paper Prof. Geikie summarises in the form of an excellent table the succession he has adopted for Europe. This table I have somewhat abridged and placed alongside my own classification in such a way as to show their points of agreement and disagreement.

In this table he groups all the English Boulder-clays older than, and I suppose including, the Chalky Boulder-clay in his third group, or epoch of maximum glaciation. But there is yet an older glacial group mentioned, of the age of the Weybourn Crag, during which the ground moraine of the great Baltic glacier, underlying the "Lower diluvium" of Germany, is supposed to have been formed. Can this epoch be the equivalent of my Older Pleistocene epoch? Unfortunately the Boulder-clays and sands of this epoch occurring in the Trent Basin have not been traced into East Anglia. Their relationships with the Contorted Drift, White Sand, and Cromer Tills of Norfolk are therefore unknown, and it is impossible to say with certainty whether the Early and Middle Pennine Boulder-clays, and the Quartzose Sand are any of them as old as the Weybourn Crag, but what evidence there is seems entirely against such a supposition. We must, therefore, regard the deposits of Prof. Geikie's third group as belonging partly to my Middle Pleistocene and partly to my Older Pleistocene epoch, and regard such an early deposit as the Weybourn Crag as not being represented in the Trent Basin, but marking the commencement of the Older Pleistocene epoch.

From Professor Geikie's table it seems that he regards climatic changes as furnishing the most satisfactory basis for the classification of Pleistocene deposits; physical changes, such as have occurred in the distribution of land and water, not being made use of for this purpose. In fact the succession simply changes alternately from Glacial to Interglacial. Possibly this method of classifying the deposits may prove to be the best in the long run, although it is in striking contrast to that adopted for the older rocks. However this may be, in studying the deposits of the Trent Basin, it was found most convenient to base the divisions chiefly upon physical considerations, such as the abnormal condition of ice-flow which obtained at one time in the Midlands of England; an ice-flow which brought into the Trent Basin an assemblage of rock fragments quite

unlike those which had been laid down by the earlier glaciers. I refer to the spreading of easterly and southerly rocks, such as chalk, flints, and Lias limestone and fossils over the older formations to the west and north-west, by an ice-flow which moved in a direction contrary to or across that of previous or subsequent ice movements.

In the Midlands of England the Older Pleistocene series consists of two thick deposits of tough Boulder-clay, separated from each other by a thick, false-bedded bed of sand or gravel. These deposits are not local, but on the contrary have been found retaining their lithological characteristics at such widely separated points as Gelston near Grantham, Leicester, Nottingham, Burton, and Ashbourne. The boulders are mainly of Pennine origin, but there are a few more distant erratics. Flint and chalk are quite absent, although the deposits occur within a few miles of the Cretaceous escarpment.

It has been suggested that these Older Pleistocene deposits were formed when the local glaciers entered the lowlands, and that the easterly rocks were thrust over them by the brushing aside of the local ice by the pressure of a great Scandinavian ice-flow. But the deposits themselves when examined in detail do not seem to support this view, for the line of demarcation between the two is quite sharp, and when the succession is anything like complete the Early and Middle Pleistocene Boulder-clays are separated by sands which clearly indicate open water. It only seems possible to account for this absence of local glaciers when the Scandinavian ice advanced over this country, on the assumption that it occurred during a period of submergence. It must be admitted that the opposition, just now, to such a view is very strong; an opposition, I think, based on very inadequate grounds.

During Older Pleistocene times the mountains of Great Britain stood well out of the sea, and as the climate became more and more severe the glaciers radiated from the hills, spread over the partially submerged low-lands, and deposited the great beds of non-flinty, silty, Boulder-clays, tills, and sands. In these silty clays, deposited long distances from the hills, the proportion of well striated stones is very large, indeed much larger than in the moraines formed in the mountain valleys. This arises from the fact that by the time the ice had reached the Midlands the glaciers in the hills had become so thick that very few cliffs were sufficiently high to shed stones on their upper surfaces; the transported rocks being mainly derived from the bed of the ice. It is quite possible that the British ice passed into the German Ocean and became confluent with the Scandinavian ice at this particular epoch; but, however this may be, it is quite certain that the Continental ice was unable to override what is now the Trent Basin.

At the close of the Older Pleistocene epoch the climate again became warmer, but in the succeeding Middle Pleistocene epoch cold conditions again supervened, but this time accompanied by a submergence. During this epoch it is possible the Moeltryfaen, Macclesfield, Gloppa, and Wicklow high-level shell gravels were formed. Owing to this submergence there seems to have been an

absence of great glaciers in the British Isles, and the Scandinavian glacier passed unchecked up the easterly valleys of England towards the central watershed; for the Chalky Boulder-clay becomes a mere silt with an occasional flint in such sheltered places as Market Bosworth and Abbots Bromley. It must also be remembered that when the mountains of the British Islands were well out of the water and nourished great glaciers, the moisture-laden south-westerly winds would be precipitated in some measure before they reached the Scandinavian peninsula, whereas when these islands were partly submerged the precipitation would be on the continental uplands, and the Scandinavian glaciers would reach their greatest development. The chalky gravel which rests upon the chalky clay and encumbers all, or almost all, the southerly and westerly watershed of the Trent does not contain molluscan remains, although the ice-sheet of that date presumably passed over the floor of the German Ocean, yet to the west of the watershed, and in such straits as those of Silverdale and Biddulph, shell fragments are very numerous. Why, if the Scotch, Irish, and Cumbrian ice-sheet was able to form shell gravels at a height of 1360 feet in Wales, 1200 feet in Wicklow, and 1150 feet at Macclesfield, was it unable to form them in the central, south-eastern, and northern portions of the Trent Basin? And why was the Scandinavian glacier unable to form shell gravels in East Leicestershire? The gravels and sands are there in force, but not the shells. Rather the high level gravels of Wales are truly marine deposits, and the flints they contain were carried from the east by bergs carved from the Great Scandinavian Glacier which occupied the easterly valleys of England and not from Antrim. According to this view the gravels were formed partly during mild and partly during cold conditions of climate. One explanation of the absence of molluscan remains in the gravels to the east of the central watershed is that the Straits of Dover were not very wide, and that the northern part of the German Ocean was blocked by ice, leaving the enclosed area too brackish for mollusca to flourish in, and also that in interglacial times the German Ocean was dry land.

Professor Geikie's third epoch, a glacial one, would therefore seem to require further subdivision into five distinct epochs marked by a possibly continuous but varying depth of submergence. There is no proof, other than that furnished by the widespread nature of both the sands and Boulder-clays, and their marked lithological peculiarities, that these epochs indicate great climatic changes, but the evidence is distinctly in favour of such a supposition. From the table showing "The Glacial Succession" it will be seen that this means seven distinct cold epochs.

On the advent of warmer conditions, at the close of Middle Pleistocene times, Britain was again elevated, and the Trent began to deposit its high-level gravels, and clear out the Boulder-clays from its valley. Some of these gravels are between 70 and 80 feet above the alluvial plains of the present valley, and all terraces above about 30 feet show signs of great surface disturbance. From the trend of the ridges and furrows of these surface deposits

the glaciers would appear to have come down the valley from the west rather than wholly from the valleys of the Derwent and Dove. There is no evidence to show that there might not have been several glaciers in Newer Pennine times. On this point I remarked, six years ago, "I have only been able to show the existence of one period of glaciation during this epoch, but there might have been two or even more, separated by considerable intervals of time." According to Professor Geikie there were three—his fifth, seventh, and ninth epochs. In these Later Pleistocene times the direction of the ice-flow was, as the surface disturbances show, again in accordance with the present local features of the country, the direction of the ice-flow which formed the Great Chalky Boulder-clay having been quite an abnormal one.

THE GLACIAL SUCCESSION.

Older Pleistocene.		1. Weybourn Crag. Ground-moraine of Great Baltic Glacier.	Glacial.
		2. Forest-bed of Cromer.	Interglacial.
Middle Pleistocene.	Early Pennine B.C. Quartzose Sand. Middle Pennine B.C. Melton Sand. Great Chalky B.C. Chalky Gravel.	3. Lower Boulder-clays of Britain. Epoch of maximum glaciation.	Glacial.
Newer Pleistocene.		4. Continental condition of British area.	Interglacial.
		5. Upper Boulder-clay of Britain.	Glacial.
	Interglacial Alluvium.	6. Britain again probably Continental.	Interglacial.
	Later Pennine B.C.	7. Ground moraines, terminal moraines, etc., of British mountain regions.	Glacial.
		8. Britain again probably Continental.	Interglacial.
		9. Local moraines in mountain valleys.	Glacial.

VIII.—GLACIAL GEOLOGY: OLD AND NEW.

By T. MELLARD READE, C.E., F.G.S., F.R.I.B.A.

THE NEW.

THE new school of glacial geology has found a champion in Mr. Percy Kendall, who, in ten pages of this MAGAZINE (November, 1892, pp. 491–500), attempts a reply to some of my criticisms.[1] Since then Dr. G. F. Wright's work, entitled "Man and the Glacial Period," has made its appearance, and in this Mr. Kendall is allowed 44 pages to explain his views of the glacial phenomena of the British Isles.

Mr. Kendall asks for "a clear exposition" of my views under no less than seven heads, at the same time stating that it would take two years' issue of this MAGAZINE, with no end of double numbers,

[1] Glacial Geology: Old and New, GEOL. MAG. July, 1892, pp. 310–321.

to deal with them properly. Judging by the length of his reply and the ground covered by it, the estimate is no doubt a moderate one. I shall therefore, to save time and space, refer Mr. Kendall to the numerous papers of mine on glacial geology which, at his request, I some time since presented him with.

Mr. Kendall's reply deals only with two sections of the subject, viz., the Distribution of Erratics and the Molluscan remains. I presume they have been selected as his strongest points, and I was in hopes to have gained some important information in the way of facts that would be helpful in any honest attempt to interpret the phenomena. Instead of this I find that information well known to glacial geologists, through the labours of Mackintosh and others, including myself, trotted out as if it were new. These facts of distribution are, in my opinion, as I have frequently explained, quite irreconcilable with the Irish Sea Glacier hypothesis. Mr. Kendall seems to think that if he can show any grouping of boulders in the Boulder-clay, or indeed anywhere on the drift area, he has a sufficient answer to my criticisms; and in proof of this grouping he quotes as authorities the observations of geologists whose experiences are much newer even than the new geology. Although not prepared to accept Mr. Kendall's *ipse dixit* on the points either of grouping or proportionate distribution of erratics, I have not the slightest indisposition, for the sake of argument, to granting him all he states. It is perhaps not a sign of generosity on my part, for the reason that it does not, in my opinion, alter the bearing of the evidence at all.

It is admitted that Lake District rocks, together with Scotch rocks, are found in greater or less proportion all the way from Macclesfield to Moel Tryfaen. It has never been explained on the Irish Sea glacier hypothesis how they come to be distributed and intermixed over such a wide area, and this is the information I have in vain been seeking. In Dr. Wright's book it is very clearly shown (pp. 58–60) how the Alpine boulders found on the Jura were proved by Guyot to have been conveyed to their positions by a glacier. The proof was simple and convincing. All the boulders derived from the right side of the Rhone clung to that side, while all the boulders derived from the left side clung to the left side, and *neither the one nor the other crossed over*. If all the Lake District rocks were found in a trail from Cumberland to Macclesfield, and the Scotch rocks in a trail from Wigtown or Dumfries to Carnarvonshire *and none crossed over*, the Irish Sea glacier would "score." This is not the case; the rocks occur over the whole area even according to the new glacialists and are inextricably intermingled at all horizons according to my observations.

Until information is given which will harmonise these observations with the work of the Irish Sea glacier as conceived by its latest supporters,[1] it seems a waste of paper and printing ink to

[1] In this connection the communication from Mr. Deeley (GEOL. MAG. p. 573–4), is well worth studying.

discuss any other points, especially bearing in mind the two years' lease of this Journal we are assured will be required for a full consideration of glacial phenomena.

Before, however, leaving the subject it will be interesting to examine the map of the British Isles in Dr. Wright's book, on which the lines of the Irish Sea glacier are laid down by Mr. Kendall—not in black and white, but in red. We have been prepared from time to time for the evolution this glacier has undergone to fit it to the new facts of glacial history as they arose, but I confess to feeling staggered at the "evolutions" it is put through, when I read the graphic description of what is euphoniously called the "Easting" of the Irish Sea glacier, and the production of the Solway glacier, by a cleavage which took place at Ravenglass by the pressure which forced it against the Cumbrian coast. "The 'Easting' motion carried it up the Solway Frith, its right flank spreading over the low plain of northern Cumberland, which it strewed with boulders of the well-known 'Syenite' (*granophyre*) of Buttermere." . . . . "Under the pressure of an enormous head of ice this stream rose from sea-level, turned back or incorporated the native Cumbrian glacier which stood in its path, and having arrived almost at the watershed between the northern and southern drainage, it swept round to the eastward and crossed over the Pennine watershed, not, however, by the lowest pass, which is only some 1400 feet above sea-level, but by the higher pass of Stainmoor, at altitudes ranging from 1800 to 2000 feet." . . . . "This Stainmoor glacier passed directly over the Pennine Chain past the mouths of several valleys, and into Teesdale, which it descended and spread out in the low grounds beyond." . . . . "The other branch of the Solway glacier passed up the valley of the Irthing and over into the Tyne, and out at sea at Tynemouth. It carried Scotch granites with it," etc.

These be "fairy tales of science," indeed, and we naturally ask ourselves on what is all this large superstructure of theory built? I confess I can find no satisfactory answer—it is beyond me, and Mr. Kendall does not help us. Grant whatever conditions may be asked for, especially such as no one has had experience of, and grant them in any required magnitude, and it is wonderful what engineering feats (in the imagination) may be performed.

For my own part I have been used to sober reality, and prefer the old fashioned careful weighing of evidence. When it becomes necessary to invent imaginary conditions to do imaginary work instead of rigorously reasoning out the probabilities of geological facts—all too few in many cases—I shall leave the seemingly congenial occupation to the poets and romancers of the science, and confess myself entirely unfitted for the prosecution of scientific investigation.

REVIEWS.

I.—A Catalogue of British Jurassic Gasteropoda. By W. H. Hudleston, M.A., F.R.S., Pres.G.S., and Edward Wilson, F.G.S. 8vo. pp. xxxiii. and 147. (London: Printed for and Published by the Authors, and Dulau & Co., 1892.) Price 7*s.* 6*d.*

A CONSIDERATION of the mass of Geological literature shows every year the greater need, not merely of indexing our knowledge but of tabulating the facts that have been accumulated. The mere catalogue of publications is valuable in its way to scientific workers, if brought out at regular intervals; but far more valuable are those works which, like the present one, summarize our knowledge on particular subjects.

The labour of cataloguing our British Fossils was for long in abeyance, until happily a start was made in the excellent Catalogue of British Fossil Vertebrata, by Messrs. Smith Woodward and Sherborn. We have much pleasure now in announcing the publication of another work that enumerates one group of British fossils—the Gasteropoda of the Jurassic rocks. This work, like the one before mentioned, is not a simple list of the known species, but a careful record of the well-established species, with full references to the original figures and authorities, and to the geological formations and principal localities. The nomenclature has been subject to critical revision, and all synonyms, as well as names of rejected and doubtful species, are noted in an appropriate manner. Such a work can only be adequately done by those having special knowledge; and in the present instance the work has been undertaken and accomplished by the highest authorities. Thus Mr. Hudleston has for many years made a particular study of the Gasteropoda of the Oolitic rocks, and the results of his labours have been published partly in this Magazine, and partly in the volumes of the Palæontographical Society; while Mr. Wilson has devoted himself more especially to the Liassic Gasteropoda, and his contributions on the subject are well known to readers of the Geological Magazine.

In their present work, the authors enumerate, in one list, all species from the Lower Lias to the Portland Beds; and they give a separate list of the Rhætic species, which "though not strictly Jurassic," are included, so as to indicate the scanty beginnings of the Jurassic Gasteropod fauna. These are supplemented by lists of Foreign species of doubtful occurrence in British strata, and of "species" not accepted. It will be noticed that the Purbeck Gasteropods are omitted, and we judge that this is due to the fact, that at present the species have not been fully worked out. Moreover the authors remark that, "The identification in British Jurassic rocks (below the Purbecks) of terrestrial and freshwater Gasteropoda in beds associated with marine bivalve and other fossils, cannot be unreservedly accepted without some strong confirmatory evidence." The species of *Helix*, *Hydrobia*, *Planorbis*, etc., that have been described are inserted with a query.

In glancing over the pages of this work, we are glad to find that comparatively few changes in nomenclature are introduced. We have been prepared for the abolition of the Jurassic *Phasianella*—the species are now included under *Bourguetia*; and also for the abandonment of *Eucyclus* in favour of *Amberleya*. *Chemnitzia* (so far as Jurassic species are concerned) remains almost wholly a Liassic genus; one species is retained for a Corallian form, but the Great Oolite species are queried, and others are mostly assigned to *Pseudomelania*. *Monodonta lævigata* becomes an *Ataphrus*. *Eulima*, *Pterocera*, *Scalaria* and some other genera are no longer recognized as Jurassic. Where subgenera have, for biological purposes, been introduced, they are placed in a subordinate position; as with *Ptygmatis* and *Nerinella*, which are arranged under the genus *Nerinæa*. *Euspira* likewise is included under *Natica*. This plan is eminently satisfactory to the geologist.

No attempt is made to indicate the zones in which species occur, and this would have been quite impossible, except in the cases of certain species obtained and described by the authors themselves, or enumerated by other authorities in recent years. Attention was not paid in old times to minute horizons, and even now-a-days the collector will find difficulty in obtaining *in situ* specimens that would satisfy the quite legitimate demands of the palæontologist. Sowerby described some of his species from Drift specimens; and we are glad to find that the authors, in assigning a locality to each species, have, so far as possible, given the first place to the type locality, or to the locality where a foreign species has first been noted in Britain. In future works of the kind it would be useful if the type locality were printed in italics.

With regard to questions of dates and priority the authors remark, "A person might spend the greater part of his life in hunting up such evidence as would be required to satisfy a court of law upon these points, which ought to be relegated to an international committee whose decision should be final."

The census given by the authors curiously enough records exactly 1000 species of Gasteropods from the Lias and Oolites, to which 15 may be added for the Rhætic species. About 150 doubtful forms are rejected.

The volume, printed as it is on thick paper, almost equals in bulk that of Morris' Catalogue, of which the second edition was published nearly forty years ago. Hence it may be judged that a complete Catalogue of British Fossils will now occupy many volumes. It is most satisfactory to note that the present work is brought out uniform in size and binding with the Catalogue of British Fossil Vertebrata.

We sincerely hope that others may now be stirred up to continue the good work which has been commenced, and so far carried out with such excellent results. Great labour, and a certain amount of drudgery, must always be incurred in preparing catalogues of this description. These however are not the most serious obstacles to the continuance of the work. Not every working palæontologist,

who might be ready to assist, would be prepared to undertake the responsibility of publication. Authors may do their work as a labour of love; but publishers are usually animated by other motives. We must however state, that the issue of the Catalogue of Vertebrata, to which we have referred, owes much to the enterprise of the Publishers, Messrs. Dulau & Co. We fear that their laudable efforts have been attended by loss. In the present instance we believe the authors have undertaken the entire cost of publication. Geologists should bear this in mind, and even if they are not specially interested in Vertebrata and Jurassic Gasteropoda, they should cheerfully and readily support the undertaking, for only by so doing can the great work of cataloguing our British Fossils be successfully accomplished.

II.—The Jurassic Rocks of the Neighbourhood of Cambridge. By the late Thomas Roberts, M.A., F.G.S. 8vo. pp. 96. (Cambridge: at the University Press. London: C. J. Clay and Sons, 1892.) Price 3*s.* 6*d.*

THIS work, which has been carefully edited by Mr. Henry Woods, serves as a fitting memorial of the labours of its author among the Jurassic rocks of the eastern-midland counties. It formed the subject of the Sedgwick Prize Essay for 1886, and has since been to some extent amplified; but the author, who had hoped still further to extend its scope, unfortunately did not live to see the accomplishment of this task.

The strata to which attention was directed are those from the Oxford Clay to the Kimeridge Clay, inclusive; and the main questions to be worked out related to the limits of the intervening Corallian division. A good deal of work was done, many years ago, by Prof. Seeley, and further information was gathered by Prof. Blake, Mr. Hudleston, and others; to whose labours and to those of other geologists due credit is given. Much remained to be done in working out the palæontological horizons or zones in this essentially argillaceous series of strata, for rock-beds are only occasionally developed, as at Upware, Elsworth, and St. Ives. To this work Mr. Roberts devoted especial attention, and most valuable results have followed.

In the Oxford Clay of the district he recognizes three well-marked zones, *in ascending order*, as follows (the figures should have been reversed):—

3. *Ammonites Duncani* and *A. Jason* (the *Ornati* group of Ammonites) of St. Neot's.
2. *Waldheimia impressa*, at the base of the St. Ives clay-pit.
1. *Ammonites perarmatus*, *A. crenatus* and *A. oculatus*, and the *Cordati* group of Ammonites, of the St. Ives clay-pit.

No beds so old as the Kellaways division of Wiltshire (zone of *Ammonites calloviensis*), are anywhere exposed. The fossils of the higher beds accord well with those known in other areas, but we question whether the zone of *Waldheimia impressa* can be regarded as more than a local sub-zone. It is noteworthy that *Ammonites Lamberti*, which occurs at this horizon elsewhere, and is sometimes

taken as a zonal index, is not recorded by Mr. Roberts. He refers later on (p. 77) to the grouping adopted by Prof. Phillips, and remarks that the Oxford classification would apply equally well for the Cambridgeshire district. We may take it, therefore, that Mr. Roberts intended simply to indicate the local zones, without implying that they would be of general application.

Turning to the Corallian Rocks, a careful study of the fossils shows that the Elsworth and St. Ives Rocks are approximately of the same age, and that they represent, in part at any rate, the Lower Calcareous Grit of other areas; a conclusion that bears out the views expressed (with less confidence) by Messrs. Blake and Hudleston.

Overlying the Elsworth rock is the clay denominated Ampthill Clay, by Prof. Seeley, and this formation and its fossils are very fully described, so far as the area near Cambridge is concerned. The evidence goes to show that in mass this Clay represents the Upware Limestone, thus including both Coralline Oolite and Coral Rag. The general assemblage of fossils agrees in this view, which would include these beds in the zone of *Ammonites plicatilis*. The occurence together of *Ostrea deltoidea* and *Gryphæa dilatata* in the Ampthill Clay, serve also to connect it with the Corallian Rocks, for both species occur in those strata in Dorsetshire. Prof. Seeley had placed the Upware Limestone above the Ampthill Clay.

Another point of interest in Mr. Roberts' work, is the fixing of a plane of division between the Ampthill Clay and the Kimeridge Clay. Phosphatic nodules had previously been noticed in the Kimeridge Clay, but it had not been seen that they occur in a fairly constant manner at the base of it. The Lower Kimeridge Clay is well developed in the district, but the author has been unable to detect any Upper Kimeridge, unless it be in the uppermost part of the section at Roslyn Hill. The occurrence of *Ammonites biplex*, *Lucina minuscula*, *Discina latissima*, and other species, would seem to justify a more confident opinion with regard to the Upper Kimeridge; as is indeed held by Prof. Blake.

Concluding portions of this work deal with the Correlation of the strata with other English deposits, and with those in the Paris Basin, the Jura, and the neighbourhood of Hanover. The very full lists of species, all so carefully verified, from many localities and horizons in these Upper Jurassic Rocks, will render the work most valuable to all workers on the subject.

III.—Extinct Monsters: A Popular Account of some of the larger forms of Ancient Animal Life. By the Rev. H. N. Hutchinson, B.A., F.G.S., with Illustrations by J. Smit and others. London: Chapman and Hall, 1892. 8vo. with 24 full-page Illustrations and 38 Illustrations in the text; pp. xx and 254. (Price 12*s*.)

MAN is distinguished from other animals by the higher development of his mental faculties, and one of the earliest lines along which his thoughts have ever delighed to travel, beyond the mere

pursuits of his daily life, and beyond his capacities for loving and hating, is that of the embodiment of the wonderful and the mysterious. Nature in all her varied forms and moods speaks to the mind of man, as the nurse or parent speaks to the little child, and all her tales are full of strange and weird pictures.

The myths and traditions of all nations teem with marvellous accounts of monsters, grotesque or terrible, and it would seem as if those peoples who inhabited sea-coasts, or went down to the sea in ships, as the old Vikings and Norsemen used to do, or the ancient Greeks and more modern Chinese, always had the largest assortment of bogies of all sorts in stock. A glance at the deities of Egypt and of Ind, or at the pictured dragons of Japan, at the Centaurs, Harpies, Hydras, Chimæras, and Tritons of the Greeks, will show how the human mind has always delighted to revel in imaginary monsters, many of which were doubtless discovered by the priests of their various religions to be extremely useful to overawe and strike terror into the minds of the ignorant and superstitious masses.

It seems strange that whilst the active imagination of man in past ages was busy everywhere in *inventing* all kinds of marvellous and uncanny creatures, and often laboured hard to depict them graphically enough in stone, or bronze, or terra-cotta, there should have existed, tens of thousands of years before, in Europe, Africa, and America, and no doubt in Asia also, beasts more strange than ever the mind of man had conceived in his wildest moments of delirium or poetic fancy.

Of some of these once-living monsters the author of the present little work has ventured to give us a pictorial notion, assisted by his artist Mr. J. Smit and others; nor has his effort been wanting in success, and even if, in some cases the author and artist seem to have been less happy in making the dry bones live again, we must make due allowance for the many difficulties by which their self-imposed task has been surrounded. Imagine the dismay of a fashionable West-end tailor who should be ordered to outfit a Hottentot in elegant evening dress; or still more, to cut out garments for a gorilla! What wonder then if the combined efforts of author and artist have, in some instances, failed to make the artificial hides they have constructed fit gracefully on such incongruous beasts as *Triceratops* or *Stegosaurus*, or to induce *Brontosaurus* gracefully to tread the earth once more.

The pictures in Mr. Hutchinson's book,—which by the way do not include anything like all the monsters which we know almost completely at the present day,—have impressed upon us, more than any other work, the enormous advances which palæontological and geological discoveries have made in the past 35 years.

Let us for a moment recall the six crowded galleries of the old British Museum at Bloomsbury, into which were compressed not only all the then known fossil remains in the largest collection in this country both of Vertebrata and Invertebrata, but also the finest Mineralogical collection in the world, with the largest series of Meteorites preserved in any one Museum.

We remember the Ichthyosaurs and Plesiosaurs, the many odd bones of extinct reptiles, some of whose uncouth shapes Professor Owen had endeavoured to reconstruct, out of his inner consciousness, as the German Professor is said to have reconstructed the Camel. We recall the skeletons of the gigantic Irish Deer, the elephant-footed "Moa" from New Zealand, the *Megatherium americanum*, and the *Mastodon*; the skull of the *Sivatherium* and the Carapaces of the *Glyptodon* and the *Colossochelys*.

Turn now to the new galleries of the Natural History Museum, Cromwell Road, they are not *overcrowded*, although full; the Mineralogical Collection has a gallery 260 feet in length by 50 feet in width, entirely devoted to the display of this fine collection, whilst Geology is provided for in eight spacious galleries, far larger than any of those in the Old Museum. In the Geological galleries the gigantic Sloth from South America is seen climbing its tree, and near it a fine and perfect skeleton of the allied *Mylodon gracilis*, and a carapace of the *Glyptodon* with head, feet, and tail added. Instead of one "Moa" there are now six skeletons of these great extinct wingless birds. There is a nearly perfect skeleton of Steller's Sea-cow (*Rhytina gigas*), the largest of the Sirenia, and, alas! now quite exterminated since the year 1780. There is a complete restoration of *Tinoceras ingens* presented by Professor Marsh, from Wyoming Territory, with six horns on its skull; there are two skulls of *Brontops*; there are three skeletons of Gigantic Irish Deer; there is the *Archæopteryx*, the long-tailed fossil bird from the Oolite; there are also the *Dimorphodon* and the *Rhamphorhynchus*, both long-tailed forms of Pterodactyles, as well as many short-tailed forms. There is the original of the *Scelidosaurus Harrisoni*, a dinosaur from the Lias of Dorset, and the complete skeleton of *Pariasaurus Baini* from the Trias of South Africa; and, though we have only parts of many great Dinosaurs, yet, thanks to Prof. O. C. Marsh in America, and to M. Dollo in Brussels, we know what *Iguanodon* and many of the American Dinosaurs were like, and now we see them clothed in flesh by the author of the book before us, and we say advisedly, "there were monsters in those days" without a doubt.

We do not propose to discuss this book here. The author indulges in no rodomontade, but gives a careful and readable account of the wonderful discoveries which modern geological research in the Rocky Mountains, and in many other parts of the world, has brought to light. The twenty-four *full-page* illustrations are admirably executed, and there are thirty eight others in the text. There is a freshness about the whole thing which suggests "Alice in Wonderland." The book is a safe book to put into the hands of the young, and cannot fail to interest geologists of all ages. It will make an admirable and attractive New Year's book, which every one should buy and read for themselves.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 23rd, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "Outline of the Geological Features of Arabia Petræa and Palestine." By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

The region may be considered as physically divisible into five sections, viz.:—(i) The mountainous part of the Sinaitic Peninsula; (ii) the table-land of Badiet-el-Tîh and Central Palestine; (iii) the Jordan-Arabah valley; (iv) the table-land of Edom, Moab, and the volcanic district of Jaulân and Haurân; and (v) the maritime plain bordering the Mediterranean.

The most ancient rocks (of Archæan age) are found in the southern portion of the region; they consist of gneissose and schistose masses penetrated by numerous intrusive igneous rocks. They are succeeded by the Lower Carboniferous beds of the Sinaitic peninsula and Moabite table-land, consisting of bluish limestone with fossils, which have their counterparts chiefly in the Carboniferous Limestone of Belgium, and of a purple and reddish sandstone (called by the author "the Desert Sandstone," to distinguish it from the Nubian Sandstone of Cretaceous age), lying below the limestone. The Nubian Sandstone, separated from the Carboniferous by an enormous hiatus in the succession of the formations, is probably of Neocomian or Cenomanian age, and is succeeded by white and grey marls, and limestones with flint, with fossils of Turonian and Senonian ages. The Middle Eocene (Nummulitic Limestone) beds appear to follow on those of Cretaceous age without a discordance; but there is a real hiatus notwithstanding the apparent conformity, as shown by the complete change of fauna. In Philistia a calcareous sandstone in which no fossils have been observed is referred to the Upper Eocene; for the Miocene period was a continental one, when faulting and flexuring was taking place, and the main physical features were developed—*e.g.*, the formation of the Jordan-Arabah depression is referable to this period.

In Pliocene times a general depression of land took place to about 200–300 feet below the present sea-level, and littoral deposits were formed on the coasts and in the valleys. To this period belong the higher terraces of the Jordan-Arabah valley. The Pliocene deposits consist of shelly gravels. Later terraces were formed at the epoch of the glaciation of the Lebanon Mountains, when the rainfall was excessive in Palestine and Arabia.

The volcanoes of the Jaulân, Haurân, and Arabian Desert are considered to have been in active operation during the Miocene, Pliocene, and Pluvial periods; but the date of their final extinction has not been satisfactorily determined.

2. "The Base of the Keuper Formation in Devon." By the Rev. A. Irving, B.A., D.Sc., F.G.S.

In a paper published in the February number of the volume of the Quarterly Journal for the current year, the author definitely

accepted the breccia which is clearly marked on the left bank of the Sid at Sidmouth as the base of the Keuper, but he had not then satisfactory data for determining a similar basement-line in the country between the valleys of the Sid and Otter, where the Keuper is repeated by the great Chit-rock Fault. Since then he has received information from the Rev. Dr. Dixon of Aylesbeare, mentioning the occurrence of breccia at several points on the east side of the Otter, and has subsequently visited the district, and with Dr. Dixon traced the breccia (the true base of the Keuper) along the left bank of the Otter, which for many miles seems to mark the western limit of the Keuper in Devonshire.

As results, (i) the palæontological difficulty which the occurrence of *Hyperodapedon* east of Ottermouth presented is now removed; (ii) the statement made in the last paragraph on page 71 of the author's paper in the February number of the Quarterly Journal needs some modification; (iii) the geological maps of the Devon area require considerable revision; (iv) data are furnished which enable us to estimate the thickness of the Upper Bunter at not more than about 100 feet; and (v) points of interest in the physiography of the country are indicated.

3. "The Marls and Clays of the Maltese Islands." By John H. Cooke, Esq., F.G.S.

The following deposits (in ascending order) occur in the Maltese Islands:—I. Limestone; II. *Globigerina*-limestone; III. Clays; IV. Greensands; V. Upper Coralline Limestone. The Marls and Clays forming the subject of this communication are No. III. of this list. They lie conformably upon the *Globigerina*-limestone, and so obscure is the line of demarcation between the two, and so striking the similarity of their fossils, that the clay may be considered as an argillaceous division of the formation upon which it rests. The upper part of the *Globigerina*-limestone is referred to the Hornerschichten of the Vienna basin, and the Clay to the Schlier. The separation between the clay and greensands is sometimes, though not always, complete, and occasionally the greensands are absent, and the coralline limestone rests directly on the clay. The thickness assigned to the clay by Dr. Murray (20 feet) is probably not far wide of the mark. A description of the lithological characters of the deposits of the clay division, based on microscopic evidence, is given. They consist largely of tests of foraminifera and minute fragments of minerals, and contain nodules of ochreous clay. A list of fossils of the clays is appended, including an addition of 31 species of Foraminifera to the 122 contained in Dr. Murray's list.

II.—December 7th, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.

The President announced that the American Philosophical Society will celebrate the one hundred and fiftieth anniversary of its foundation at Philadelphia, from May 22nd to May 26th, 1893. Fellows of the Geological Society who propose to be in Philadelphia during that week, and who may wish to participate in the celebration as

representatives of the Society, are requested to communicate with the Assistant Secretary, Burlington House, W.

The following communications were read:—

1. "Note on the Nufenen-stock (Lepontine Alps)." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

In 1889 the author was obliged to leave some work incomplete in this rather out-of-the-way portion of the Lepontine Alps. In the summer of 1891 he returned thither in company with Mr. J. Eccles, F.G.S., and the present note is supplementary to the former paper. The Nufenen-stock was traversed from north to south, and a return section made roughly along the eastern bank of the Gries Glacier. Gneiss abounds on the north side of the Nufenen Pass, followed by rauchwacké and some Jurassic rock. On the flank of the mountain are small outcrops of rauchwacké and of the so-called "Disthene-schists" (both badly exposed), followed by much Dark-mica schist, often containing black garnets. Higher up is a considerable mass of Jurassic rock with the "knots" and "prisms" which have been mistaken for garnets and staurolites, but Dark-mica schists set in again before the summit is reached. They continue down the southern flank of the peak; but rather north of the lowest part of the water-shed, between Switzerland and Italy, the "Disthene-schist" is again found, followed by a fair-sized mass of rauchwacké.

The return section gave a similar association in reverse order; and both confirmed the conclusions expressed by the author in 1890 as to the absence of garnets and staurolites from Jurassic rocks (with belemnites, etc.), and the great break between these or the underlying rauchwacké (where it occurs) and the crystalline schists, in which garnets often abound, of the Lepontine Alps. The crystalline schists and the Mesozoic rocks are thrown into a series of very sharp folds, which, locally, presents at first sight the appearance of interstratification.

2. "On some Schistose 'Greenstones' and allied Hornblendic Schists from the Pennine Alps, as illustrative of the Effects of Pressure-Metamorphism." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author describes the results of study in the field and with the microscope of (*a*) some thin dykes in the calc-schist group, much modified by pressure; (*b*) some larger masses of green schist which appear to be closely associated with the dykes; (*c*) some other pressure-modified greenstone dykes of greater thickness than the first. The specimens were obtained, for the most part, either near Saas Fee or in the Binnenthal.

These results, in his opinion, justified the following conclusions:

(1) That basic intrusive rocks, presumably once dolerites or basalts, can be converted into foliated, possibly even slightly banded, schists, in which no recognizable trace of the original structure remains.

(2) That in an early (possibly the first) stage of the process the primary constituents of the rock-mass are crushed or sheared, and thus their fragments frequently assume a somewhat "streaky" order;

that is to say, the rock passes more or less into the "mylonitic" condition.

(3) That next (probably owing to the action of water under great pressure) certain of the constituents are decomposed or dissolved.

(4) That in consequenc eof this, when the pressure is sufficiently diminished, a new group of minerals is formed (though in some cases original fragments may serve as nuclei).

(5) That of the more important constituents hornblende is the first to form, closely followed, if not accompanied, by epidote; next comes biotite (the growth of which often suggests that by this time the pressure is ceasing to be definite in direction), and lastly a water-clear mineral, probably a felspar, perhaps sometimes quartz.

(6) That in all these cases the hornblende occurs either in very elongated prisms or in actual needles.

The author brings forward a number of other instances to show that this form of hornblende may be regarded as indicative of dynamometamorphism; so that rocks where that mineral is more granular in shape (cases where actinolite or tremolite appears as a mere fringe being excepted) have not been subjected to this process.

3. "On a Secondary Development of Biotite and of Hornblende in Crystalline Schists from the Binnenthal." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

Both the rocks described in this communication come from the Binnenthal, and were obtained by Mr. J. Eccles, F.G.S., in the summer of 1891. They belong to the Dark-mica schists described by the author in former papers, and have been greatly affected by pressure. In each a mineral above the usual size has been subsequently developed. In the rock from near Binn this mineral is a biotite; the dimensions of one crystal, irregular in outline and having its basal cleavage roughly perpendicular to the lines indicative of pressure are about ·175″ × ·03″. The other mineral, from the Peak of the Hohsandhorn, is a rather irregularly formed hornblende, the crystals (which lie in various directions) being sometimes more than half an inch long. The exterior often is closely associated with little flakes of biotite. The author discusses the bearing of this fact, and the circumstances which may have favoured the formation of minerals, so far as his experience goes, of an exceptional size.

Some remarks also are made on the relation of these structures developed in the Alpine schists to the various movements by which these rocks have been affected, and on the general question of pressure as an agent of metamorphism.

4. "Geological Notes on the Bridgewater District in Eastern Ontario." By J. H. Collins, Esq., F.G.S.

The plateau of the Bridgewater district consists chiefly of gneiss and mica-schist, with subordinate beds of white marble, quartz-conglomerate and quartzite, and some veins of "giant-granite." The general dip of the gneissose series is eastward.

The author notes the effect of frost in splitting off flakes of the

gneissose rocks and conglomerates, especially on the bare glaciated surfaces, and suggests that many of the smaller and shallower lakelets may have originated by this process.

The conglomerates are described as gneisses and mica-schists, with subordinate pebble-beds.

The occurrence of gold in quartz-veins near Flinders, and at Madoc, is noted; and amongst other economic products are the micas of the granites, asbestiform actinolite, and marble. The author discusses the mode of origin of the granite, marble, and actinolite-rock.

CORRESPONDENCE.

SELENOLOGY.

Sir,—Pressure of other work has caused me to overlook until now Mr. Peal's short but suggestive article in the last number of the Geological Magazine (Nov. 1892, pp. 500–502). Perhaps it may not be now too late to call Mr. Peal's attention to certain queries and suggestions published by myself in 1889 (App. ii. Note O, to my little work on "Metamorphism of Rocks"). I venture to think that some of these, suggested by an attempt to look at the matter from the chemico-geological standpoint, have hardly occurred to Mr. Peal. I will only note now two points: (1) that other tides than oceanic aqueous tides have to be allowed for; (2) that volcanic action is not under all circumstances dependent on water as an agent.

Wellington College, Berks, *25th Nov.*, 1892. A. Irving.

Sir,—The last paragraph of Mr. A. R. Hunt's letter (p. 573) is the most ingenious instance of misrepresentation by selective quotation that I have seen for a long time. Against such an antagonist I cannot contend. So I leave him to enjoy the illusion that particular difficulties are best solved by general ignorance (see paragraph three of his letter), and to metamorphose not only the rocks of Devon, but also my papers to his heart's content.

December 9th, 1892. T. G. Bonney.

MISCELLANEOUS.

Cambridge University.—Prof. A. H. Green, M.A., F.R.S., F.G.S, Professor of Geology in the University of Oxford, has just been elected an Honorary Fellow of Gonville and Caius College, Cambridge, of which he was an old student and a former Senior Fellow.

Professor Sir Richard Owen, K.C.B., F.R.S.—We regret to announce the death of Professor Sir Richard Owen, K.C.B., F.R.S., etc., which took place at Sheen Lodge, Richmond Park, at three o'clock, on the morning of Sunday, December 18th, 1892, in his 89th year. We hope to give a record of his life and work next month.